KNOWLEDGE
AN ILLUSTRATED
MAGAZINE OF SCIENCE
SIMPLY WORDED—EXACTLY DESCRIBED

LONDON: MAY 1, 1891.

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THE ARTIFICIAL REPRODUCTION OF RUBIES AND OTHER PRECIOUS STONES.

By VAUGHAN CORNISH, B.Sc., F.C.S.

IN speaking of the artificial reproduction of precious stones, it must be understood that we are dealing with processes which have nothing in common with the *imitation* of gems. Ingenuity and skill, and even a certain amount of scientific knowledge, have been exercised in imitating diamonds, pearls, and so forth; but the art is merely one of counterfeit, the materials produced at most deceive the eye, and they possess neither the chemical composition nor the properties of the natural objects which they simulate, except the qualities of colour and lustre. In these two points the counterfeit is often sufficiently good to deceive any save a practised eye; but it must be borne in mind that the intrinsic value of a gem, apart from the fictitious value due to rarity, depends not solely on beauty of colour and lustre, but on the hardness of the material which preserves, for instance, a cut ruby from deterioration for centuries. It is the character of permanence which gives to precious stones their pre-eminent value among other beautiful objects.

But the ruby may not only be imitated more or less successfully by colouring a dense and highly refracting kind of glass; it can also be *reproduced*, that is to say, the thing itself can be prepared in the laboratory. Such a product is termed an *artificial* ruby, and the common acceptation of the word appears to carry with it a prejudice, as if it were intended to convey that the object would be a ruby were it not that rubies are formed naturally, whereas this was produced through the intervention and contrivance of man. So much is this the case that if, as may well happen, rubies should prove to be produceable of sufficient size for the purposes of the jeweller, there will certainly be a feeling against wearing the stones so produced as ornaments, due to the idea that the jewel is in some sort a sham. This is a natural but mistaken conception. A mineral—the ruby, for instance—is a body having a certain chemical composition and other equally important characteristics, such as those of its crystalline form, specific gravity and hardness. The body is formed through the operation of certain laws of chemical combination and of crystallization. Whether the opportunity for the operation of these laws occurs in the bowels of the earth or in the crucible of the chemist, cannot be rightly held to affect the identity of the body produced.

The reproduction of minerals has been carried on for the last forty years, chiefly among a small school of French chemists, and is to be regarded as a part of the great work of chemical synthesis.

Synthetical or constructive work only begins at an advanced stage in the study of an experimental science, and the synthesis of minerals was necessarily preceded by many years of analytical investigation. In the first decade of the present century, the laws which regulate the proportions in which the elements enter into chemical combination were already established. At this time the art of chemical analysis was being rapidly developed, and its methods were applied to the examination of minerals. It was found that the elements they contained were present in those particular, definite proportions which had been found to be characteristic of chemical combination. It was during this epoch also that the laws of crystallography were first established. The chemical composition and the crystalline form were recognised as the two most essential characteristics of each mineral species, although other properties were duly taken account of, as, for instance, specific gravity, hardness and colour. Thus mineralogy was put on a sound footing as a classificatory and analytical science; but the next step in advance, the introduction of synthesis, the building up of the minerals, appeared to be beyond the power of the experimentalist. It was found that substances prepared in the laboratory, having the same chemical composition as natural minerals, did not possess their other characteristic features. Thus Heavy Spar has the same chemical composition as the sulphate of barium produced in the laboratory; but whereas the first is a hard, well-crystallized body, the second is formed as a fine powder, destitute of coherence and of crystalline form.

Again, silica occurs in nature as the well-known Rock Crystal, but in the ordinary chemical process it is obtained as a gritty powder. The silicates, a class of substances comprising many well-crystallized gems, such as the garnet, could only be reproduced artificially as *glasses*, transparent indeed and coherent, but without crystalline structure. Such failures gave rise to the impression that there was some special influence or force at work in nature in the production of minerals which could not be commanded by the chemist, just as it was supposed that the substances produced in the vegetable and animal kingdoms needed the action of the so-called *vital force*, and were incapable of reproduction in the laboratory. The belief in this *vital force* was dispelled when the advance of chemistry solved the problem of the synthesis of organic

bodies. Similarly it was found that by modifying the ordinary methods of the chemical laboratory so as to imitate more closely the conditions obtaining in the formation of rocks and of mineral veins, compounds could be produced, having not only the chemical composition, but the other characteristics of the natural minerals. For instance, in the case of barium sulphate, the material is produced in the laboratory by the interaction of a solution of a barium salt and a solution of a sulphate. It was found that if special devices were adopted so that the two solutions only came in contact with extreme slowness, the forces of crystallization came into play, and the barium sulphate separated out with the form, hardness, and other characteristics of the natural mineral. The processes previously employed had been too rough and hasty, and had not reproduced the conditions of Nature's laboratory. Water plays a part in most of the ordinary chemical processes, but under the usual conditions water cannot be raised to a temperature above 100° C., since it is then converted into steam. In the depths of the earth great pressures come into play, and when there is at the same time a high temperature, water, kept by pressure in the liquid state, acts under very special conditions. By heating silicates, such as glass, with water in strong steel vessels, so that a high temperature and great pressure are obtained, it is found that the silica is separated in the form of quartz, in crystals reproducing in the most complete manner the minute peculiarities, the surface markings and striations, of the natural mineral. For the production of corundum, a *flux* is employed, *i.e.* a substance which fuses at a moderate temperature and in which the alumina dissolves, to separate out on cooling in the crystalline form. The colour of the ruby—one of the varieties of corundum—is due, not to the substance of which it is mainly composed, but to a very small proportion of a colouring matter. By the addition of a small amount of a suitable material the red colour is obtained in the product of the laboratory, and by varying the colouring material sapphire and oriental emerald have been obtained. So far the size of the specimens has been small, one-third of a carat being about the maximum for rubies. The carat is equal to four grains. A cut ruby weighing a grain would be suitable for one of the smaller stones of a ruby ring. In the process of cutting, however, the weight is generally reduced by one half, so that the largest specimens yet produced are not adapted for employment as ornaments. They are, however, used in the jewelling of watches. The details of the method employed at the present time in their production are as follows. The chemically precipitated amorphous alumina is heated with barium fluoride, or a mixture of the fluorides of the alkaline earths, which acts as a flux, and a trace of bichromate of potash is added to impart the red colour. The addition of carbonate of potash, which renders the fused mass alkaline, furthers the formation of larger crystals. The heating is kept up for several days, at the end of which time a plentiful crop of crystals is obtained. Although the aggregate weight obtained in one operation amounts to some pounds, the individual crystals are, as has been said, small in size. It is frequently contended that the fact of reproduction is the only essential point, and that the size of the crystals produced is of little importance from the scientific point of view. It must, nevertheless, be allowed that the interest of this work will be much increased when products are obtained which will compare in size and beauty with those occurring in nature.

Of other gems, some—as the garnet and the spinelles—have been prepared; others, as the emerald, have hitherto proved less tractable. In the case of turquois, the artificially prepared substance has the chemical composition and the appearance of the natural stone; but inasmuch as the laboratory product behaves differently under certain conditions, as, for instance, when heated, it must be considered as an approximate reproduction only, if not looked upon as a mere imitation. The pearl is formed of aragonite, a mineral readily reproduced by evaporating a hot solution of carbonate of lime. The peculiar beauty of the pearl is, however, due to the structure resulting from its mode of growth. It would be rash to hazard an opinion as to whether this structure could be imparted by methods at the disposal of the chemist.

But the great problem in the artificial production of gems is the preparation of the diamond, and this problem is still unsolved. Popular prejudice has relegated the attempt to the same category as the endeavour of the alchemist to transmute the baser metals into gold. The aim of the alchemist was once a legitimate object of scientific research. In the light of modern ideas on the nature of chemical elements it is so no longer. The endeavour to obtain the element carbon in that transparent crystalline form in which it is found in nature, has certainly nothing in common with the work of the alchemist. Yet the light in which the attempt is viewed by the majority is still that so graphically described by Balzac in his ingenious novel, *La Recherche de l'Absolu*. Balthazar Claes devotes his life to the endeavour to reproduce the diamond, and "people would scarcely speak to him—a man in the nineteenth century seeking the philosopher's stone. They called him an alchemist, and said he might as well try to make gold. As he passed by in the street people pointed him out with expressions of pity or contempt." The want of success which has hitherto attended the efforts of the Balthazars of real life is perhaps scarcely to be wondered at. In the case of other minerals the successful reproduction has generally been achieved only after the minute study of the mode of natural occurrence, and this has afforded guidance as to the best means of imitating the natural process of formation. It is only of recent years that the diamond has been found in its original matrix, so that materials have been wanting on which to base experimental methods. The chemical nature of the body, a combustible substance, is so different from that of the ruby and most other gems, which are oxides or oxidized materials, that the methods to be employed for its production will probably involve the application of different principles. There is no reason, however, to regard the problem as insoluble. When sufficient guiding data have been obtained, skill will not be wanting to imitate in the laboratory the conditions under which Nature has worked in the formation of this most beautiful product of the mineral world.

THE HOUSE CRICKET.

By E. A. Butler.

FEW domestic insects have succeeded in inspiring such widely different sentiments in the minds of their hosts as the House Cricket. To most people it is far better known by the evidence of the ears than of the eyes. Its shrill chirping, prognosticatory, according to popular belief, of cheerfulness and plenty, reveals the performer's presence when no trace of its person can be discerned; and like the similar sound made by its near relative, the grasshopper, it is one which there is great difficulty in localising or tracing to its origin. Distinct and intensely penetrating

though this "shrilling" is, yet most people find it a perplexing task to decide exactly from what quarter it proceeds. This constitutes an element of mysteriousness, and it is not surprising that the invisible minstrel should have been credited with occult influences. The feelings with which the sound has been regarded have accordingly varied with the disposition of the hearer, from superstitious reverence to downright dislike and extreme irritation. While to Milton, for example, "the cricket on the hearth" seemed no unsuitable accompaniment of thoughtful solitude, when the devotee of "divinest Melancholy" retires to

> Some still removed place . . .
> Where glowing embers through the room
> Teach light to counterfeit a gloom,

on Gilbert White, the naturalist of Selborne, the chirping of crickets had quite an opposite effect. Speaking of the Field Cricket, which is in most respects much like its cousin of the house, he remarks: "Sounds do not always give us pleasure according to their sweetness and melody; nor do harsh sounds always displease. We are more apt to be captivated or disgusted with the associations which they promote than with the notes themselves. Thus the shrilling of the field-cricket, though sharp and stridulous, yet marvellously delights some hearers, filling their minds with a train of summer ideas of everything that is rural, verdurous, and joyous."

If poet and naturalist do not agree here, still less are they in accord in other instances; if to the former the cricket is "Little inmate, full of mirth," "always harbinger of good," one whose song is "soft and sweet" (!), to the latter it is a "garrulous animal," keeping up a "constant din," "a still more annoying insect than the common cockroach, adding an incessant noise to its ravages." And while the simple and easy-going rustic life of olden times might tolerate and even enjoy this incessant clatter, the state of nervous tension at which so much of present-day life is lived will no doubt lead most people to agree with the naturalist here, rather than with the poet, and vote the cricket a household nuisance. The noise upon which such different views have been held is apparently a love-call, and is accordingly produced only by the males, the female crickets being, in fact, through the absence of the requisite machinery for chirping, absolutely dumb. To the cause of the noise we shall recur presently; meanwhile, we may consider the zoological position and the structure of the insect.

FIG. 1.—HOUSE CRICKET (*Gryllus domesticus*).

As a family the crickets enjoy a wide distribution, and in this country five species have been met with, though for some reason best known to themselves, only one has domesticated itself. The family is called *Gryllidæ*, and is closely allied to those of the grasshoppers and locusts, forming with them one of the great divisions of the order Orthoptera, viz. that of the "leapers." To another section of the same order, viz. the "runners," it will be remembered, the cockroach belongs. Our English domestic species (Fig. 1) is called *Gryllus domesticus*. At first sight a cricket strikes one as being not unlike a grasshopper in general form, the resemblance being caused chiefly by the great proportionate length and elevated position of the hind legs. In body, however, it is broader and flatter than a grasshopper, and in other respects is sufficiently distinct to be regarded as the type of a different family.

The mouth organs bear a close resemblance to those of the cockroach, as a comparison of the accompanying figures with those of KNOWLEDGE, vol. xii., p. 218, will testify. As one looks in the insect's face, the greater part of the mouth organs is concealed by a not very stout flap, hinged above and shaped like a cheese-cutter; this is the *labrum*, or upper lip. On lifting it, like the visor of a knight's helmet, there is disclosed a pair of stout, dark brown, horny, toothed jaws (*mandibles*, Fig. 2), which are used not merely to divide the food, but also as excavating implements, to hollow out retreats into which the insects can retire in the day-time or when alarmed. These mandibles again, when closed, completely cover the rest of the mouth organs; on their removal, the secondary jaws, or *maxillæ*, come into view (Fig. 3); these are very much like the cockroach's, the inner lobe (*lacinia*) being tipped with two sharp teeth, and received for protection's sake into a groove of the outer (*galea*), and they are furnished with a pair of five-jointed palpi. Beneath, or rather behind them, is the *labium*, showing again a similar structure to that of the prototype, and equally obviously composed of a pair of jaws which have coalesced, *i.e.* have become united into a single organ in their

FIG. 2.—MANDIBLE OF CRICKET.

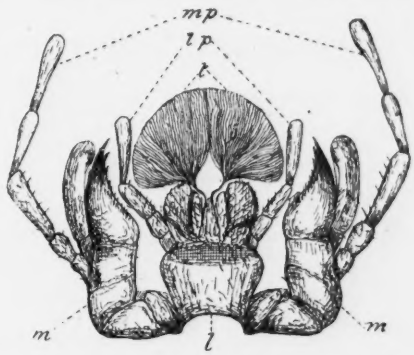


FIG. 3.—MOUTH ORGANS OF CRICKET. *m*, maxillæ; *mp*, maxillary palpi; *l*, labium; *lp*, labial palpi; *t*, tongue.

basal portion; this, too, carries a pair of palpi. The chief difference between the two insects is to be seen in the appendage to the labium in its centre, which is called the *lingula*, or "tongue." This is a most marvellous and exquisite structure, and deservedly a great favourite with microscopists. As shown in the figure, it is pressed out of place. On opening the mouth it will be seen on the floor, rising into a grooved, hollow, fleshy eminence. When flattened out it is found to be a kidney-shaped, leaf-like expansion, strengthened throughout by radiating fibres of chitinous material, which, when highly magnified, show a beautiful mosaic structure. Kitchen refuse of various kinds constitutes the food of these creatures, and a good deal of moisture as well seems to be necessary for their well-being. No doubt this curious tongue helps them in drinking. They have been accused of gnawing

holes in stockings hung before the fire to dry, in order to satisfy their cravings for moisture. Hence, also, it is not an infrequent experience to find them drowned in pans or jugs of liquid.

The House Cricket is more or less of a pale brown colour throughout, and, unlike the cockroach, it is fully winged in both sexes, and, therefore, has no need of man's agency to supplement its powers of locomotion. It flies with an undulatory motion, making long rising curves in the air, and dropping at regular intervals. The wings are extremely beautiful objects; in fact, the house cricket contains so many exquisite and delicate structures, that anyone who has a few hours to spare and can devote them, with a good microscope, to the dissection of the insect, will find ample material for interesting study and observation. There are two pairs of wings, the upper pair being more or less horny and exceedingly different in males and females; and the under pair thin and membranous, and similar in both sexes. When closed, the right upper wing partly overlaps the left, and the under wings project in the form of long, tapering, rod-like pieces beyond the tips of the fore wings, extending about half as far again as these.

The fore wings are much broader than a casual glance would suggest, seeing that only about two-thirds of their width lies flat along the back, the other third being bent down at right angles to the rest, and lying close along the side. Those of the female are very regularly veined, there being two systems of nervures proceeding in opposite directions, one on each side of the stout ridge at which the wing is bent. But the wings of the male (Fig. 4) are extremely peculiar, and it is in them that the power of chirping resides. There is the same division into

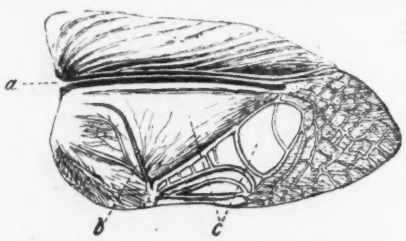


Fig. 4.—Right Fore wing of Male Cricket. *a*, line of bending; *b*, file; *c*, drum.

two areas as in the female, but the hinder section, *i.e.* the one that lies on the back, has its veins distributed very irregularly. A stoutish nervure runs straight across this near its base, and then beyond it a large clear triangular area is left almost devoid of nervures. At the apex of this, nearer still to the tip of the wing, is another similar, but smaller and four-sided, patch, with a single, pale, delicate nervure running across it, and the rest of the wing is covered pretty closely with a network of nervures. If, now, these wings be turned over and examined beneath, it will be found that the straight nervure aforesaid is crossed transversely by a large number of little hard ridges, giving it the appearance of an extremely fine file. These are much too small to be seen with the naked eye, but a moderate magnification coupled with careful focussing soon brings them into view. When the chirping is to be produced, the insect bends the fore part of the body slightly downwards, and then slightly raising the fore wings, rubs them rapidly across one another; during this motion, the file of one rubbing against the surface of the other produces a creaking vibration, which is greatly intensified by the clear, open plates above-mentioned, which are therefore called "drums." It will now be evident why the females are mute; they have neither "file" nor "drum," and hence are physically incapable of "singing."

It is clear from the above that the chirping is in no true sense of the word either a voice or a song, being quite unconnected with the respiratory organs; it is a purely external and mechanical sound, comparable, as a means of expressing sentiments, rather with the human device of clapping the hands, or flipping the fingers, than with the utterance of sounds with the mouth. Of course it is not to be expected that an insect should make any noise with its mouth other than that produced by eating, since the mouth does not, as is the case with us, communicate with the breathing organs. The entrances to these are in the cricket, as in all other insects, along the sides, and any sound that might be produced in them by the passage in and out of the air would be more strictly comparable with the voice of vertebrate animals; some insects, as for example, the common bluebottle-fly, are able to produce a noise in this way, and may therefore be truly said to possess a voice. But that is by no means the rule, and the sounds insects produce are in general the result of the friction of external parts upon one another.

The hind wings of the cricket are exceedingly delicate, and are each strengthened by about fifty nervures radiating fan-wise from the base. As about half these nervures are weaker than the rest, the weak ones being placed alternately with the strong ones, the whole wing can be folded up lengthwise like a fan, and this accounts for its pointed form as it protrudes from beneath the upper wing. It is this peculiar method of straight, longitudinal folding that has caused the name Orthoptera (*straight*-winged) to be given to the order.

Of course the power of chirping implies the power of hearing. It is only natural to suppose that the male crickets would long ago have abandoned the habit of serenading (if, indeed, they had ever perfected it) if their mates had not been able to recognise their attentions. It is rather curious, however, that this insect, notwithstanding its living in our houses, and the considerable curtailment of its field of quest for partners consequent thereupon, should have preserved almost as strongly as its outdoor relative this power of chirping; one cannot help feeling a suspicion that, if this vigorous minstrelsy be merely of an amatory nature, either the gentler sex in the cricket world have become extremely coy, or else there is a vast deal of wasted energy on the part of their swains. However that may be, as the power of recognition of this call seems as though it must be an important matter in cricket economy, we naturally look about for some special apparatus suitable for the detection of sounds, of a much more indubitable character than is generally met with in insects. And the search is soon rewarded. It is only necessary to examine the *tibia*, or shank, of the fore legs, just below its junction with the thigh, to find an organ to which it is difficult to assign any other function. Here, on the flattened outer edge is a long, oval, transparent, membranous disc, stretched over a corresponding aperture in the walls of the leg (Fig. 5), and exactly opposite it, on the other side of the leg, there is a similar, but round and much smaller disc; between these two, in the centre of the hollow shaft of the leg, is a bladder-like expansion of the main breathing-tube of the leg. Numerous curiously shaped nerve-endings, having the peculiar form of those

Fig. 5.—Fore Tibia of Cricket, showing auditory organ (*a*).

of special sense, are distributed at this spot, and the action of the complex apparatus seems to be such that the membranous disc, vibrating in response to the chirping of some distant individual, communicates its motion to the air within the breathing-tube, which in its turn affects the neighbouring nerves, thus enabling the insect to perceive the sound.

Projecting from the hinder part of the female's body is a long ovipositor, consisting of a double boring implement, used in depositing the eggs in suitable situations. Large numbers of eggs are laid, and the course of development is similar to that of the cockroach or bed-bug, the eggs yielding small, active, six-legged creatures, something like their parents in form; after a series of moults, these attain by progressive changes, but without any pause in their activity or suspension of their functions, the adult size and form, acquiring wings only at the last moult. The metamorphosis is thus incomplete.

Two long, unjointed, tapering appendages, pointing backwards, project from near the extremity of the abdomen in both sexes. They are furnished abundantly with very fine hairs, and are probably sense organs, possibly giving notice of impending danger from behind.

Crickets are pugnacious insects amongst their own kind; notwithstanding similarity of habits, however, they are often found inhabiting the same houses as cockroaches. But it seems probable that the steadily advancing armies of the latter insect will, in the course of time, either exterminate them, or compel them to take to an out-door life. This latter they are not averse to doing in the summer time even now. But from the way in which they hug the kitchen fire, it seems as if artificial warmth is essential for them in the winter.

CLUSTERING STARS AND STAR-STREAMS.

By J. E. Gore, F.R.A.S.

THE general tendency of the stars to gather into groups, more or less marked, is perhaps indicated by their ancient division into constellation figures. In the Northern Hemisphere we have the well-known groups of the "Plough" (Ursa Major), "Cassiopeia's Chair," the "Sickle" in Leo, Corona Borealis or the Northern Crown, and Orion; and in the southern hemisphere the Southern Cross, Scorpion, Corvus, &c. The "Dolphin's Rhomb," the head of Hydra, and the group near the binary star 70 Ophiuchi also form examples of this clustering tendency.

That in some of these groups, at least, the connection is real and not merely apparent is shown by the community of "proper motions" discovered by the late Mr. Proctor in the five stars of the "Plough," β, γ, δ, ϵ, and ζ[*]—a connection afterwards verified by Dr. Huggins's spectroscopic observation of their motion in the line of sight. We have a similar case in "Cassiopeia's Chair," where several of the stars in this well-known group seem to be moving in the same general direction through space.

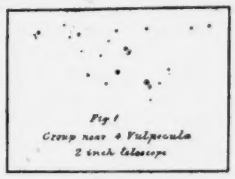
Among the lucid stars, the most remarkable examples of this clustering tendency are found in the smaller groups, such as the Hyades and Pleiades. In the latter cluster—perhaps the most remarkable group of stars in the heavens—six stars are visible to ordinary eye-sight, but some persons gifted with keener vision can see a larger number.* There is a tradition that seven stars were originally visible to average eyes, but that one disappeared at the capture of Troy. With reference to this supposed disappearance of the "lost Pleiad," Professor Pickering has recently discovered that the spectrum of Pleione (which forms a wide pair with Atlas) bears a striking resemblance to that of P. (34) Cygni, the so-called "temporary star of 1600." The similarity of the spectra shown by these two stars suggests that Pleione may—like the star in Cygnus—be subject to occasional accessions of light, which may, perhaps, account for its possible visibility to the naked eye in ancient times. Examined with a telescope the Pleiades show an enormously increased number of stars—even with an opera-glass a considerable number may be seen—and in a photograph of the group, taken at the Paris Observatory with an exposure of three hours, no less than 2,326 stars can readily be counted in a space of about 3 square degrees. In this remarkable picture, smaller aggregations of stars are visible; for instance, Alcyone, the brightest of the whole group, forms one of a small cluster of some ten stars, and Maia and Merope have several faint stars near them. A common proper motion in many of the brighter stars of the Pleiades shows that here also we have a family of stars travelling through space together.

The Hyades also form a remarkable naked-eye group, with the brilliant red star, Aldebaran, as their leader, but the component stars are not so closely crowded as in the Pleiades group. I am not aware whether the Hyades have yet been photographed.

Another well-known cluster is the Præsepe, or the "Beehive," in Cancer. The stars composing it are, however, scarcely perceptible to the unaided eye, and in ancient times this cluster, from its nebulous aspect, was probably ranked as a nebula, and perhaps placed in the same class with the great nebula in Andromeda, which was also known to the earlier astronomers.

Coma Berenices is another example of a scattered cluster. Here the stars are brighter, and may be well seen with an opera-glass.

Among clusters a little beyond the limits of naked-eye vision, there are many interesting examples of star clustering which may be seen with a binocular or good opera-glass. One of the most remarkable of these surrounds the star 5 Vulpeculæ. I give two drawings of this curious little asterism, one (Fig. 1) as seen by myself with a 2-inch telescope, and the other (Fig. 2) as drawn by Mr. Espin, with a reflecting telescope of 17¼ inches aperture. The tendency of the brighter stars to run in lines will be noticed, and the curious grouping of fainter stars towards the left of the larger diagram is also remarkable. This group should be photographed. It is surrounded by Milky Way light, according to both Boeddicker and Heis.



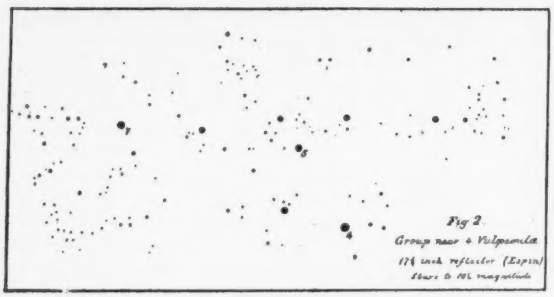
About 2¾ degrees preceding the bright star Pollux I see a small cluster of stars, of about the 7th and 8th magnitudes, which, with a binocular field-glass, very much resembles the Pleiades as seen with the naked eye. The stars 10, 11 and 12 Geminorum (north preceding μ

* Dr. Auwer's subsequent determinations have, however, shown that in three of these stars, β, γ, and δ, the "proper motion" is small and doubtful. We have, however, a quintuple system in ϵ, ζ, Alcor, and the telescopic and spectroscopic companions of ζ.

* Miss Airy is said to have seen 12, and Möstlin (according to Kepler) no less than 14.

Geminorum) also lie in a small cluster of stars, which may also be well seen with a binocular.

The well-known double cluster χ Persei may be seen with an opera-glass, but a telescope is necessary to see the component stars, and the larger the instrument the greater the number visible in these wonderful objects, which, like many somewhat similar clusters, lie in the Milky Way. This twin cluster has been well photographed at the Paris Observatory, and also by Mr. Roberts. On the Paris photograph—at least, in the paper print in my possession—the clusters are clearly resolved into stars



with no trace of outstanding nebulosity, suggesting that the component stars are probably at nearly the same distance from the earth.

The cluster 39 Messier, between π' and 71 Cygni, may be well seen with a binocular, in which it somewhat resembles the Pleiades as seen with the naked eye.

Another fine open cluster will be found a little north, following β Ophiuchi. Between β and γ Ophiuchi is a remarkably blank spot. On August 15, 1890, I failed to glimpse the faintest star with binocular in a clear, moonless sky, a striking contrast to the rich region north of β. A similar blank space will be found just north of the stars π and ϕ Aquilæ (north of Altair). On September 3, 1886, I could only see glimpses of very faint stars with the binocular in a sky clear and moonless, a remarkable vacuity so close to a region of bright stars, and a good example of an interesting stellar feature, namely, rich and poor regions in close proximity. I may here mention that a region of considerable extent, remarkably barren of bright stars, will be noticed with the naked eye in the northern hemisphere. This comparatively poor region, which contains no star brighter than the 4th magnitude, is bounded by Cepheus, Cassiopeia, Perseus, Auriga, Gemini, Ursa Major, Draco, and Ursa Minor, and forms a conspicuous feature in the north-eastern portion of the sky in the early winter evenings. It will be noticed that the bounding constellations all contain conspicuous stars.

Examined with a telescope, the heavens afford numerous instances of stellar aggregation. The Milky Way forms, of course, the most remarkable example, on a great scale, but among comparatively isolated groups there are numerous interesting objects. Of these, the cluster known as 35 Messier—a little north of the variable star η Geminorum—is visible in an opera-glass, but a telescope is required to see the component stars. A very beautiful photograph of this cluster has been taken at the Paris Observatory. A well-marked clustering tendency is visible among the brighter stars of the group, two, three, four, and sometimes five stars being grouped together in subordinate clusterings.

In the southern hemisphere a splendid cluster of small stars surrounds the star κ Crucis. Sir John Herschel charted 110 stars to the 7th magnitude and fainter. Some of the component stars are coloured with red, greenish, and bluish tints, which, he says, "give it the aspect of a superb piece of fancy jewellery." It lies near the northern edge of the well-known "Coal-sack," and Dr. Gould says of it: "The exquisitely beautiful cluster κ *Crucis* contains a large number of stars of various tints and hues, contrasting wonderfully with each other, when viewed with a telescope of large aperture." A drawing by Mr. Russell of this cluster, made in 1872, shows some well-marked star-streams.

Just north of ζ Scorpii is a bright cluster which I found visible to the naked eye in the Punjab sky as a hazy star of about $4\frac{1}{2}$ magnitude. With a 3-inch refractor the components were well seen.

The so-called "globular clusters" form excellent examples of the clustering tendency, but here the component stars lie so close together that their physical connection cannot be doubted.

Among groups of stars not usually classed as clusters there are many examples of this aggregating tendency visible on the stellar photographs taken at the Paris Observatory. Photographs of portions of the Milky Way in Cassiopeia, Gemini, and Lyra show the small stars to be in many places not scattered uniformly, but with a marked tendency to cluster into subordinate groups adjoining comparatively starless spaces. This is especially noticeable on a photograph of a portion of the constellation Gemini (R.A. 6h. 10m., N. 20° 20′), a little south of η Geminorum. On these photographs many cases occur in which three, four, or more stars are grouped together, often in a straight line, or nearly so, and to all appearance comparatively isolated from their surrounding neighbours. On a photograph of a rich Milky Way region in Cygnus (R.A. 19h. 45m., N. 35° 30′) taken by Mr. Roberts at Liverpool, with an exposure of 60 minutes, on which no less than 16,206 stars may be counted (in an area of about 4 degrees), similar features are noticeable.

In his observations of the Milky Way in the southern hemisphere Sir John Herschel says: "Here (R.A. 17h. 50m., S. 33°–36°) the Milky Way is composed of separate, or slightly, or strongly connected clouds of semi-nebulous light; and as the telescope moves, the appearance is that of clouds passing in a *scud*, as the sailors call it." "I could fill a catalogue with the clusters of the 6th class which are here. The Milky Way is like sand, not strewn evenly as with a sieve, but as if flung down by handfuls (and both hands at once), leaving dark intervals, and all consisting of stars 14 . . . 16 . . . 20m. down to nebulosity, in a most astonishing manner."

No. 2,908. "Cluster 7th class. The second of two stars 9m. which may be considered the leading stars of the very large and fine cluster of the Nubecula Major, which fills many fields, is of all degrees of condensation and much broken up into groups and patches. . . . The field full of grouping stars."

The tendency of the stars to run in streams is pointed out by Proctor in his *Universe and the Coming Transits* (first two chapters). Among the lucid stars the most remarkable instances of this stream-forming arrangement are found in Pisces, Scorpio, "the river Eridanus," the streams in Aquarius, and the festoon of stars formed by η, γ, α, δ, and μ Persei. The stream forming the constellation Eridanus was noticed by the ancients (as the name "river" implies), but in this case the stars are so far apart that the connection is probably more apparent than real. Perhaps the same may be said of the streams forming Scorpio and Pisces, but still they are sufficiently well-defined to attract the eye of even a casual observer. Other examples of the kind may be seen in Corona Borealis,

XUM

or the Northern Crown; in Corona Australis in the southern hemisphere; and also among fainter stars visible to the naked eye, or with an opera-glass.

But it is among the still fainter stars—those visible only with a telescope or revealed by photography—that we find the most striking examples of this stream-forming tendency. In these cases the small stars composing the streams are comparatively close together—at least, apparently so—and for this reason the evidence in favour of a real physical connection is proportionately stronger. Webb says*: "A little *n. p.* μ Sagittarii xviih. 57m., S. 18° 50′ is a spot referred to by Secchi as exemplifying in a high degree the marvellous structure which the great achromatic at Rome shows in the Galaxy. The remarks of this accomplished astronomer on the successive layers of stars are very curious: first he finds large stars and lucid clusters; then a layer of smaller stars, certainly below 12 mag.; then a nebulous stratum with occasional openings. But what he says startled him, and all to whom he showed it, was the regular disposition of the larger stars in figures 'si géométriques qu'il est impossible de les croire accidentelles. La plus grande partie sont comme des arc de spirale; on peut compter jusqu'à 10 ou 12 étoiles de la 9me. à la 10me. grandeur. . . . Se suivant sur une même courbe comme les grains de chapelet; quelquefois elles forment des rayons qui semblent diverger d'un centre commun, et ce qui est bien singulier, on voit d'ordinaire que, soit au centre des rayons, soit au commencement de la branche de la courbe, on trouve une étoile plus grande et rouge. Il est impossible de croire que telle distribution soit accidentelle.'"

I have already noticed that on the Paris stellar photographs many cases may be seen of three or more stars placed in a straight line, or nearly so. Sometimes a comparatively bright star seems to draw a train of fainter stars after it, like the tail of a comet, and occasionally a stream of stars of nearly equal brightness may be traced for some distance from their source. In the photograph of the cluster 38 Messier, this stream-formation is well marked among the brighter stars. Webb describes it as "a noble cluster arranged as an oblique cross."†

Observing with a 3-inch telescope in India, in July 1874, I noticed a beautiful cluster of stars about 4° north of λ and ν Scorpii, resembling, in shape, a bird's foot, with remarkable streams of stars. This cluster is visible to the naked eye as a star of 5 or $5\frac{1}{2}$ magnitude.

Sir William Herschel, speaking of the compressed cluster H. vi. 25 in Perseus, says, "the larger stars are arranged in lines like interwoven letters"; and, Webb says, "it is beautifully bordered by a brighter foreshortened pentagon."

From the close proximity of the component stars—of some at least of these clusters—the reality of a physical connection between them seems beyond dispute, and from analogy we may conclude, I think, that "streams" and "sprays" of stars in other portions of the heavens are, in some cases at least, due to a real and not merely an apparent connection.

From a telescopic examination of the Milky Way, Professor Holden finds numerous star-streams, and also arrangements forming "small definite ellipses" of stars, often all of the same size. . . . In certain parts of the sky, the arrangement is so intricate that no single pattern can be discovered. In most regions a little attention will show that there are several patterns, one for each of the fainter magnitudes of stars" (*Monthly Notices*, R.A.S., Dec. 1889).

In a paper in the *Monthly Notices*, R.A.S., for April 1890, Mr. Backhouse calls attention to the "straight lines and parallel arrangements of pairs, lines, and bands of stars, and also of irresolvable wisps" observed by him in a portion of the Milky Way included between the stars 15, 13, 8 Monocerotis, α Orionis, ζ Tauri, and 5, μ, ξ Geminorum, and "besides the parallelisms" he notes "a most wonderful case of *radiation of stars and wisps* in a fan-shaped group, 68 Orionis being approximately the centre." He finds a preponderance of the groupings "at an average deviation of 15° from the direction of Gould's Galactic Equator, viz. at a position angle of 345° with that great circle, and more nearly parallel with a Galactic Equator derived from Proctor's chart of the *Durchmusterung* stars, and he adds: "One conclusion derived from the investigation is that the stars and wisps in parallel lines are probably in the same region of space; and therefore that the majority of the stars—at least of those down to the 9th or 10th magnitude—in extensive tracts of the area examined are really near one another."

An examination of Dr. Boeddicker's beautiful drawing of the Milky Way seems to show that the Galaxy itself is—at least, chiefly—composed of "star-streams" and "star-sprays" and clustering groups of small stars, and does not represent a "cloven" flat disc, as was originally supposed.

Mr. Proctor pointed out that "the nebular system also shows the most marked tendency to stream-formation." In the great nebular region in Virgo and Coma Berenices, he finds that "the stars are not arranged uniformly over either region, but to some degree clusteringly with interspersed spaces relatively vacant. Now no nebula appear in the more vacant spaces, nor do nebula appear chiefly where the stars are more clustered. It is on the borders of star-clusterings, and in the breaks of star-streams, that the nebulæ show themselves, precisely as though they had taken the place of stars where star-matter began to fail." This fact, considered in connection with Laplace's Nebular Hypothesis, is very remarkable and suggestive. The nebulæ seen in the streams may possibly represent stars in their initial stage.

* *Celestial Objects*, Fourth Edition, p. 385, foot-note.
† *Ibid.*, p. 241.

WHAT IS A VOLCANO?

By the Rev. H. N. Hutchinson, B.A., F.G.S.

IN old days volcanoes were regarded with superstitious awe, and any investigation of their action would have been considered rash and impious in the highest degree. A certain "burning mountain" in the Lipari Isles, called Volcano, was considered to be the forge, or workshop, of Vulcan, the god of Fire. And so it comes about that all "burning mountains" take their name from this island in the Mediterranean.

In the present paper it will only be possible to consider two aspects of the subject of volcanoes, which may, perhaps be more suitably presented in the form of questions, viz. (1) *What is a volcano?* (8) *What are the chief phenomena of volcanic action?*

In the first place, a volcanic mountain consists of alternating sheets of ash and lava, mantling over each other in an irregular way, and all sloping (or "dipping," as geologists say) away from the centre. In the centre is a pit, or chimney, widening out towards the top so as to resemble a funnel or a cup. Hence the name "crater," which means a cup. In the centre of the cone there is frequently a little minor cone. As our readers will pro-

bably be aware, many of the lunar volcanic craters also possess these little minor cones, which are well seen in some of the larger photographs of the moon's surface. A number of cracks, or fissures, radiating from the central orifice, intersect the volcano. These get filled with lava welling up from below, and from what are called "dykes," which may be regarded as so many sheets of igneous rock —basalt or felsite, as the case may be—that have, while in a molten condition, forced their way in among the layers of ash and lava. The word "ash" is used by geologists in a special sense; and volcanic ash is not, as might be supposed, a deposit of cinders, but mostly of dust of various degrees of fineness; and sometimes it is very fine indeed. It is synonymous with the word "tuff." Pieces of pumice-stone may be embedded in a volcanic tuff, but they only form a small part. How these volcanic tuffs are formed we shall explain presently.

Dykes strengthen the mountain and tend to hold it together when violently shaken during an eruption. But notwithstanding, it sometimes happens that the whole structure is blown to pieces by some unusually violent outburst.

The shape and steepness of a volcano vary with the nature of the materials ejected. The finer the volcanic tuff the steeper and more conical is the mountain. The formation of a volcano may not be inaptly illustrated by the little cone of sand formed in an hour-glass as the sand-grains fall. The latter settle down to a certain slope, or angle, at which they can remain in their place. This is known as the "angle of repose." When the materials are coarse the angle is less. When they are fine the angle is greater. The district of Auvergne in France contains a number of very interesting extinct volcanoes, some of which were formed principally of a thick and viscous lava which slowly welled up from below, and in so doing formed round and dome-shaped little hills such as the "Puy de Dome." Vesuvius, Teneriffe, Jorullo in Mexico, and Cotopaxi in the Andes, are examples of steep volcanoes built up principally of volcanic tuff. Others, more irregular in shape, such as Kilauea in the Sandwich Islands, are largely built up by successive lava-flows. Little minor cones are frequently developed on the flanks of a volcano, which during eruptions give rise to small outbursts on their own account. They are easily accounted for by the dykes which we mentioned just now; for when the molten rock forces its way through the fissures, it sometimes finds an outlet at the surface, and, being full of steam, as soda-water is full of gas, it gives rise to an eruption. The central orifice, with its molten lava, is, as it were, a great dyke which has reached the surface and so succeeded in producing an eruption. The opening of a soda-water bottle not infrequently illustrates a volcanic eruption; for when the pent-up carbonic acid cannot escape fast enough it forces out some of the water, even when the bottle is held upright.

Lastly, every volcano is built up on a platform of stratified rocks, or strata, laid down in the usual way under water, and at some period subsequent to their formation molten matter came up from below, and found its way through them to the old land-surface which they formed. Earthquake shocks preceding the first eruption probably cracked up the strata, and so facilitated the uprise of the lava with its imprisoned steam.

The main point which we wish to emphasize is that volcanoes are *never* formed by upheaval. They must not be regarded as blisters due to the swelling or upheaval of strata, but, as we have endeavoured to explain, they are gradually built up from below, and may be compared to rubbish heaps, which grow by gradual accumulation. But in the case of volcanoes, the rubbish comes from below. It is not necessary to suppose that the subterranean reservoirs from which the molten rock is supplied, exist at any very great depth below the original land-surface on which the volcano grows up. Indeed, the evidence we at present possess, from the denuded areas of volcanic action, goes to show that this is not the case.

The old "upheaval theory" of the formation of volcanoes, once advocated by certain geologists, instead of being based upon actual evidence, or reasoning from facts, as modern scientific theories are, was a mere guess. Moreover, if the explanation we have given should not be sufficiently convincing, there is the proof furnished by the case of a small volcano near Vesuvius, whose formation was actually witnessed. It is called Monte Nuovo, or the New Mountain. This mountain is a little tuff-cone, 430 feet high, on the bank of Lake Avernus, with a crater more than a mile and a half wide at the base. It was mostly formed in a single night, in the year 1538 A.D. We have two accounts of the eruption to which it owes its existence, and each writer says distinctly that the mountain was formed by the falling of stones and ashes.

One witness says: "Stones and ashes were thrown up with a noise like the discharge of great artillery, in quantities which seemed as if they would cover the whole earth; and in four days their fall had formed a mountain in the valley between Monte Barbara and Lake Averno of not less than three miles in circumference, and almost as high as Monte Barbaro itself—a thing incredible to those who have not seen it, that in so short a time so considerable a mountain should have been formed." Another says: "Some of the stones were larger than an ox. The mud [ashes mixed with water] was at first very liquid, then less so, and in such quantities that, with the help of the afore-mentioned stones, a mountain was raised, 1,000 paces in height." These accounts are important as showing how, in a much longer time, a big volcano may be built up. They are examples, or little epitomes, of slow and vast processes which Nature vouchsafes to us, and which enable us to comprehend her actions when they are on a larger scale.

We must now consider briefly the second question. The following are the chief phenomena of a great eruption:— Its advent is heralded by earthquakes, affecting the mountain and the whole country round; loud subterranean explosions are heard, resembling the fire of distant artillery. The vibrations are chiefly transmitted through the ground; the mountain seems convulsed by internal throes due, no doubt, to the efforts of imprisoned vapours and liquid rock to find an opening. These idications are accompanied by the drying up of wells and disappearance of springs, since the water finds its way down new cracks resulting from the explosions. When at last an opening has been effected, the eruption begins, generally with one tremendous burst, shaking the whole mountain down to its foundations. Frequent explosions follow with great rapidity and increasing violence, generally from the crater. These are indicated by the globular masses of steam which are to be seen rising up in a tall column like that which issues from the funnel of a locomotive. The elastic gases in their violent ascent hurl up into the air a great deal of solid rock from the sides of the crater, after first blowing out the stones which previously stopped up the orifice.

Blocks of stone falling down meet with others coming up, and so a tremendous pounding action takes place, the result of which is that great quantities of volcanic dust are produced, generally of extreme fineness. Winds and ocean currents transport these light materials for long

distances. Recent researches show that fine volcanic dust is universally distributed over the sea. The darkness so frequently mentioned in accounts of eruptions is caused entirely by clouds of volcanic dust obscuring the daylight. The red clay deposits in the deepest and most remote parts of the ocean are now considered to be chiefly composed of oxidized volcanic dust.

Portions of liquid, or semi-liquid, lava are caught up by the steam and hurled into the air. These assume a more or less spherical form, and are known as "bombs." At a distance they give the appearance of flames. And here we may remark that the flaring, coloured pictures of Etna or Vesuvius in eruption, which frequently may be seen, are by no means correct. The huge flames shooting up into the air are imaginary—another case of a popular fallacy—but probably suggested by the glare and bright reflection from incandescent lava down in the crater.

But there is another way in which a good deal of fine volcanic dust, or ash, is produced; and it is this—the lava is so full of steam intimately mixed up with it that the steam, in its violent escape, often blows the lava into mere dust. This might be illustrated by the cloud of spray seen for a moment after a soap-bubble has burst; and we can well imagine that something like this takes place in a boiling and seething mass of lava in a crater during eruption. The steam, we ought to mention, is not dissolved in the lava, but absorbed by it, and is said to be "occluded" (hidden away).

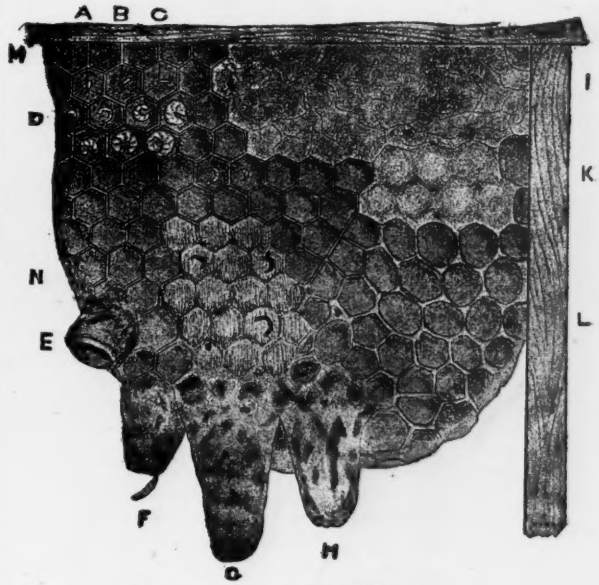
When lava-flows take place the lava does not always come from the crater, but often issues from the side of the volcano. This marks the crisis of the eruption, and now a gentle decline sets in. The volcanic forces have done their worst, and the lava-column begins to sink. Explosions decrease in violence, less ash is ejected, and finally cinders choke up the orifice; and so the volcano, as it were, chokes up itself.

So great is the force of the pent-up steam trying to escape that it frequently blows a large portion of the top of the volcano bodily away, leaving only a truncated cone; and, in some cases, a whole mountain has been thus blown to pieces. Finally, torrents of rain follow or accompany the upthrust of so much steam into the air. Vast quantities of volcanic ash are caught up by the rain, and in this way large quantities of mud are washed down the sides of the mountain. Sometimes the mud-floes are formed on a large scale, and, descending with great rapidity, bury up a whole town. It was in this way that the ancient cities of Herculaneum and Pompeii were buried up by the great Vesuvian eruption of A.D. 79. The Italians give the name *lava d' acqua*, or water-lava, to flows of this kind, and they are greatly dreaded on account of their very rapid flow. An ordinary lava-stream creeps slowly along, so that people have time to get out of the way; but in the case of mud-flows there is often no time for escape.

Into the question of the cause of volcanic phenomena we cannot enter now; but we shall have more to say in a second paper.

Notices of Books.

The Honey-Bee: Its Natural History, Anatomy, and Physiology. By T. W. COWAN, F.L.S., &c. (Houlston & Sons.) This little manual, which, though consisting of upwards of 200 pp., is scarcely larger than pocket-size, forms the natural supplement to the author's numerous works on Bees and Bee-culture. The subject is handled in an exhaustive and thoroughly scientific manner, and the book, which is written in a commendably concise style, and contains upwards of seventy figures, teems with reliable information. The labour of compilation must have been great, and the author deserves the thanks, not only of apiculturists, but of all who are interested in the anatomy and physiology of insects in general, for having put into such a compact and inexpensive form so much of the detailed results of recent scientific research. Authorities are constantly cited throughout, and the references to the copious bibliography appended supply the reader with all that is necessary to guide him in pursuing the subject further. Taking a look into a hive at the height of its activity, we are introduced to the queen "moving slowly over the combs, surrounded by a number of workers, which are constantly touching her with their antennæ, and offering her food. She stops at an empty cell, examines it by putting her head inside, then, hanging on to the edges of the comb, inserts her abdomen, and deposits at the base of the cell, to which it is attached by a glutinous secretion, a little bluish-white oblong egg." The position of the egg in the cell is altered day by day, till, sloping gradually from the upright, it eventually lies in a horizontal direction, as shown at A, B, C, in the

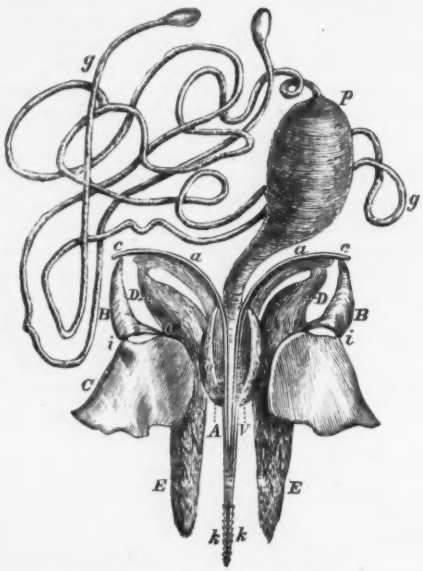


A BROOD-COMB AND ROYAL CELLS.

accompanying figure of a brood-comb. Here also are shown the growing grub, the remarkable crater-like openings of the royal cells, drone cells at K, and at N cells containing workers, some of which are just nibbling their way out through the cappings of the cells. Mr. Cowan considers that bees generally confine their honey- and pollen-collecting expeditions to within a radius of about two miles from their hives, except when food is scarce, when they will fly as far as four or five miles. By his own observations he has proved that the rate of flight may be at least as much as twelve miles an hour, *i.e.* for unweighted bees, the heavily-laden ones returning from a foraging expedition, of course travelling more slowly.

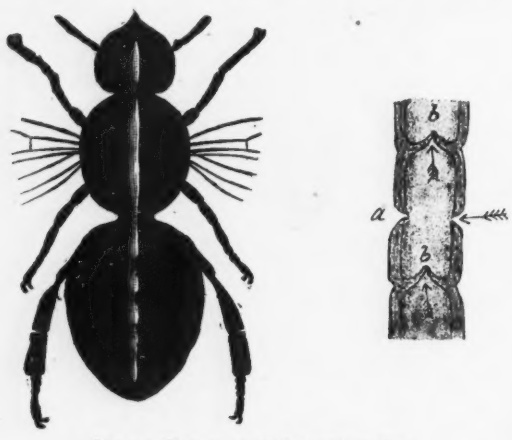
Great pains have been taken to give a clear exposition of the mechanism and method of action of the sting,

which is much more complex than might have been imagined. The accompanying figure shows the long tubular poison-gland which passes its secretion, consisting chiefly of formic acid, into the large reservoir at the base of the sting; the two lancets the latter contains may move either simultaneously or alternately, and at each stroke the



Bee's Sting and Poison-Gland.

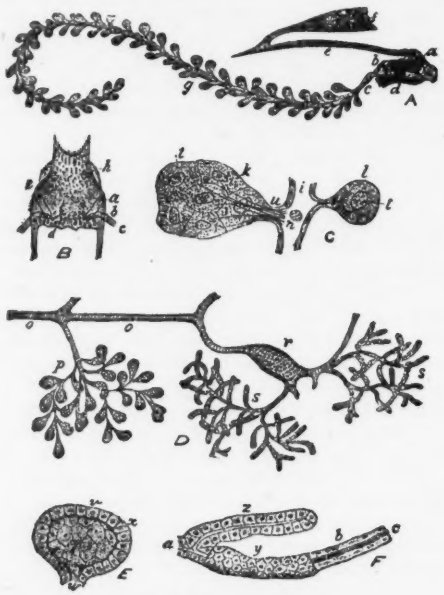
poison is forced into the wound with considerable energy through canals in the lancets themselves, and out at the openings between the barbs. Though the queen rarely stings a human being, yet the writer's experience shows that she can do so if necessary. He states also that she can withdraw her sting more easily than the workers, by moving round and giving the barb a spiral motion; this,



Dorsal Vessel or "Heart" of Bee.

he maintains, the worker could do also, but that she is in such a hurry to get off that she does not give herself time, but tears herself away, leaving the sting and its appendages behind her. Mr. Cowan has adopted the striking and effective device of showing different systems of organs separately *in situ* on the dark background of the body; one of these illustrations, exhibiting the dorsal vessel, or "heart" of the bee, is here appended; the small explanatory diagram added shows how the blood enters by the side openings of this valvular tube, and is propelled towards the head.

No subject is more debateable than the functions of antennæ, and hence much interest attaches to the chapter dealing with the researches that have been made into the structure and function of the tactile hairs, and of the curious sensory pits in these organs in the bee, which have by some authors been considered to be smell hollows, and by others an auditory apparatus. The accompanying



Salivary Glands.

figures of the salivary glands of the bee will give an idea of the neatness with which the histological illustrations are executed. Mr. Cowan has made many measurements of the cells of the comb, with the view of testing the accuracy of commonly-received notions as to their extreme regularity, and he finds that frequently considerable deviations from the normal size and shape of the cells occur. Following Müllenhoff, he maintains that "the complexity and apparent accuracy of the structure is not in the least owing to the development of a mathematical instinct in bees, or artistic dexterity, but simply to physical laws dependent on their method of work," the cells behaving "mutually like soap-bubbles, which when isolated are round, but, if touching each other, where united the film forms a perfectly flat wall." One or two misprints occur in the technical terms, as *e.g.* "vasa *dif*-ferentia" for "*de*-ferentia," and "vesiculæ seminal-*is*" for "seminal-*es*."

Celestial Motions; a Handy Book of Astronomy. By W. T. Lynn, B.A., F.R.A.S. Seventh Edition. (London: E. Stanford.) We are pleased to welcome a new edition of Mr. Lynn's very handy little manual, the sixth edition of which was reviewed in Knowledge for June 1889. In the present one the information appears to have again been carefully brought up to date, reference being made to Schaparelli's results with respect to the rotation of Mercury and Venus, and to the identity of the comet discovered by Brooks in July 1889 with what is generally known as Lexell's comet of 1770. No notice, however, is

taken of the "spectroscopic binaries" discovered at Harvard and Potsdam. There are very few misprints in the work, but we must demur to the statement on page 9 that the resulting mean distance of the moon from a parallax of 57′ 2″ is 237,300 miles. As a matter of fact the mean distance of the moon is about 238,840 miles, the average distance is *not* the mean of the maximum and minimum values of the distance, and a parallax of 57′ 2″ would answer to a distance of about 238,900 miles.—H. S.

THE PLEIADES CLUSTER, AND ITS PROBABLE CONNECTION WITH THE MILKY WAY.

By A. C. RANYARD.

THE Pleiades lie a little to the south of the Milky Way, in a line with the Hyades—the three great stars in the Belt of Orion, and Sirius, the brightest star in the heavens. This striking chain of jewels lies nearly parallel with the Milky Way, just outside its southern border. It forms part of a great belt or stream of bright stars first noticed by Sir John Herschel,* and subsequently more closely studied by Dr. B. A. Gould,† which appears to girdle the heavens very nearly in a great circle that intersects the Milky Way at an angle of about 20°, crossing it near the margin of the Southern Cross, and in the northern hemisphere again crossing the Milky Way in Cassiopeia. This stream of bright stars, like the stream of milky light it crosses, is more striking in the southern hemisphere than in the northern, and one can hardly doubt its intimate connection with the stream of smaller stars with which it appears to be associated.

Of the twelve brightest stars in the heavens which rank as of the first magnitude or brighter than the first magnitude, seven lie in this brilliant girdle of stars, and three are intimately associated with it, being situated only just on the opposite border of the Milky Way. Taking the stars in their order of brightness according to Professor Pickering's photometric catalogue, they stand thus:—1. *Sirius*, ranked as of the −1·4 magnitude; 2. *Arcturus*, 0·0 magnitude, that is, one magnitude brighter than the first magnitude; 3. *Capella* and *Vega*, both ranked as of the 0·2 magnitude; 5. *β Orionis*, 0·3 magnitude; 6. *Canopus*, 0·4 magnitude; 7. *Procyon*, 0·5 magnitude; 8. *α Orionis*, 0·9 magnitude; 9. *α Centauri*, a double star, one component of which is of the 1·0 magnitude and the other 3½ magnitude; 10. *Aldebaran*, *α Aquilæ*, and *α Eridani*, all three ranked as of the 1·0 magnitude. Of these stars *Aldebaran*, *α* and *β Orionis*, *Sirius*, *Canopus*, *α Centauri*, and *Vega* lie in the zone of brilliant stars alluded to above, while *Capella*, *Procyon*, and *α Aquilæ* lie, at no great distance, on the opposite border of the Milky Way. According to Professor Gould, *Capella* and *α Aquilæ* lie on a well-marked branch of this great star-stream, which bifurcates during half its course round the heavens similarly to the Milky Way.

At first sight, no doubt, it seems altogether improbable that such large stars could be associated with very small and apparently distant stars; but the evidence afforded by the Pleiades group, as well as by other clusters, shows that one star differs from another star in brightness, not merely ten or a hundred times, but certainly as much as a hundred thousand times, while the small streams and closed curves of stars in the Milky Way contain stars which differ several magnitudes in brightness, and yet fall so accurately into lines and curves that we can hardly doubt their physical association with one another. The accompanying three small groups of stars have been cut from an automatically-prepared block made from Mr.

Barnard's photograph of the *Sagittarius* region. Such closed curves of stars generally surround dark spaces, or lie along the edges of dark channels. The great dark arch shown in the photograph of the *Sagittarius* region, published in the July number of KNOWLEDGE last year, seems to be a succession of such dark regions, each surrounded by curves of stars. I only refer to them here as showing that various magnitudes of stars seem to be associated together in the brighter parts of the Milky Way, and that we must not assume that there is not as great a range of actual magnitudes in and about the Milky Way as we shall see, there seems to be very little doubt, are associated together in the Pleiades cluster.

The Rev. John Michell, in a paper published in the *Phil. Trans.* for 1767, seems to have been the first to apply the doctrine of probability to the question whether the *Pleiades* group corresponds to an actual cluster of stars in space, all of which are relatively near together, or whether it probably corresponds to a series of stars at various distances from us, but all lying near to the same line of sight. Considering the views then in vogue as to the uniform distribution of stars with respect to the sun's position in space, the paper is a very masterly one. He concludes that there must be some physical connection between the numerous double and triple stars which had already been discovered by Sir William Herschel, but which were not then known to be moving under the influence of mutual gravity, and that such groups of stars as the clusters in the sword-handle of Perseus and the Pleiades must be actual clusters. Summing up, he says: "We may conclude with the highest probability (the odds against the contrary opinion being millions to one) that the stars are really collected in clusters in some places, where they form a kind of system, whilst in others there are either few or none of them."

The Pleiades group forms a very irregularly-shaped

* Sir John Herschel says of it, in his *Results of Astronomical Observations made at the Cape of Good Hope*, p. 385:—"The medial line of the Milky Way may be considered as crossed by that of the zone of large stars which is marked out by the brilliant constellation of *Orion*, the bright stars of Canis Major, and almost all the more conspicuous stars of *Argo*, the Cross, the Centaur, *Lupus* and Scorpio. A great circle passing through *ε Orionis* and *α Crucis* will mark out the axis of the zone in question, whose inclination to the galactic circle is therefore about 20°, and whose appearance would lead us to suspect that our nearest neighbours in the sidereal system (if really such) form part of a subordinate sheet or stratum deviating to that extent from parallelism to the general mass which, seen projected on the heavens, forms the Milky Way."

† Prof. Gould says, in the *Uranometria Argentina*, p. 355:—"A stream of especially conspicuous stars, which, beginning with *Orion*, includes the brightest in *Canis Major*, *Columba*, *Puppis*, *Carina*, *Crux*, *Centaurus*, *Lupus*, and the head of *Scorpius*. In the northern hemisphere its course is less distinctly marked, and it is especially indistinct in *Ophiuchus* and *Hercules*; but its general direction is indicated by the brightest stars in *Taurus*, *Perseus*, *Cassiopeia*, *Cepheus*, *Cygnus*, and *Lyra*. This belt seems to bifurcate in a manner somewhat analogous to the Milky Way. A well-marked branch diverges from the main stream, not far from *α Centauri*, traversing the Galaxy, which it spangles with the bright stars of *Sagittarius* and of the tail of *Scorpius*, and passing through *Aquila* and *Delphinus*, reunites with the principal belt in the north-preceding portion of *Andromeda*. This bifurcation is likewise much less manifest in the northern hemisphere than in the southern, the bright stars being more scattered, and the course of the divided stream less distinctly traceable."

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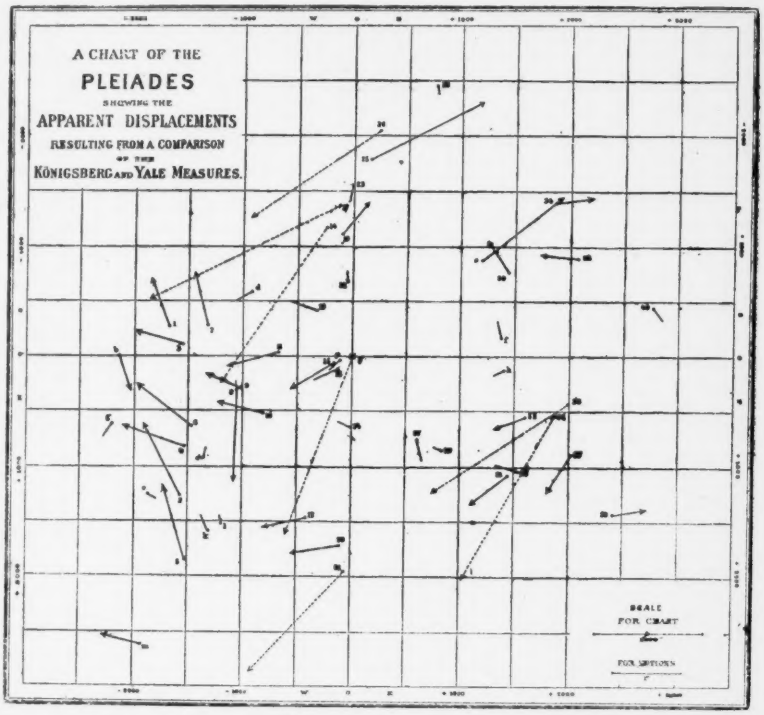
cluster, without any marked condensation towards a centre, and it would not be opposed to probabilities or unreasonable to suppose that we might be looking at two clusters superposed or projected on one another in the line of sight; if this was the case, the smaller stars might belong to one cluster, and the larger to the other and nearer cluster, and we should then not be warranted in assuming that differences in apparent magnitude amongst the stars of the group must correspond to differences in actual brightness or size of the stars. If there were two such clusters entirely unconnected with one another, we might expect to find a difference in the proper motion or drift of the two families of stars, or a difference in their spectra, which might enable us to sort out and distinguish the stars belonging to the two groups. The measurement of the relative positions of the stars in the Pleiades group has occupied the attention of several distinguished astronomers. This was one of the first problems which Bessel attacked with the Königsberg Heliometer. It occupied his attention during about twelve years, until the work was finally completed in 1841. Dr. Wolf of the Paris Observatory, Prof. Simon Newcomb, Prof. Pritchard, and ultimately Dr. Elkin of Yale, have all devoted much time and care to determining the positions of the stars of this group. The accompanying chart shows the proper motions of the chief stars of the group as determined by Dr. Elkin, by comparing his own measures made with a six-inch heliometer with those made by Bessel nearly half a century previously. The chart is copied from Dr. Elkin's memoir, which forms the first volume of the *Transactions of the Astronomical Observatory of Yale University*.* It will be seen that there are seven stars with large proper motions towards the north-west, all of them, with the exception of *Alcyone*, being small stars. They are shown with arrows having dotted or broken lines on the chart, corresponding to the amount and direction of the proper motions. With the exception of *Alcyone*, the other six lucid stars of the group have comparatively small proper motions.



In Dr. Elkin's map the larger stars are distinguished by letters. Both the letters and numbers are those used by Bessel. The map corresponds to the inverted image of the stars as they are seen in the telescope, and it must therefore be turned round through 180° to make it correspond with Mr. Isaac Roberts's photograph, or with the plate given in the January number of Knowledge for 1889. It is remarkable that the general direction of drift of these seven stars is very similar to the reversed absolute motion of *Alcyone* in 45 years as given by Prof. Newcomb, viz. 2″·61. There seems to be little doubt that these seven stars are only optically associated with the cluster, and have no physical connection with it. Of the remaining 33 stars whose positions were compared, two, viz. Nos. 8 and 25, have a considerable and similar proper motion towards the south-east, which would seem to render it probable that they are associated. The star No. 8 has, according to Prof. Pickering (see *Memoirs of the American Academy*, vol. xi., p. 214), a spectrum which shows the K line broad and differs materially from the first type of spectra exhibited by most of the other members of the group. The spectrum of No. 25 is uncertain, as it is overlapped by the spectrum of another star; 27 and 39 also have peculiar spectra. Setting these aside as probably only optically connected with the group, the remaining stars have only comparatively small proper motions, and seem to have similar spectra of the first type. There appears to be a tendency to community of drift in adjacent parts of the group, such as might well be exhibited by the stars of an irregular cluster moving under mutual attractions.

Assuming all the other stars, with the exception of the eleven referred to above, to belong to one cluster, they would all be at about the same distance from the earth, and their actual brightness may be taken to correspond to their apparent brightness. Prof. Pickering has measured the light of 298 of these stars, varying from a little below the third magnitude down to the 15·3 magnitude of the photometric scale.* There are many fainter stars in the group, though the instrument used by Prof. Pickering did not enable him to measure their brightness. Thus the Brothers Henry photographed within the same area,

* It should be mentioned that Professor Pritchard has given a chart of the proper motions of the stars of the Pleiades group in the *Memoirs* of the Royal Astronomical Society, vol. xlviii., p. 272, which does not at all agree with that given by Dr. Elkin. But the practical agreement of Dr. Wolf's measures with those of Dr. Elkin, as well as other considerations, seems to show that, although a very small probable error is claimed by Professor Pritchard, Dr. Elkin's map is probably the most reliable. I do not place much reliance on the smaller proper motions deduced by Dr. Elkin, that do not amount to half a second in a century, for such an error would about correspond to the quarter of a second of probable error of the Königsberg observations as deduced by the accurate Bessel.

* See vol. xviii. of the *Harvard Annals*, p. 202.

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THE GREAT NEBULA IN THE PLEIADES.

From a Photograph taken by Mr. Isaac Roberts, 8th December, 1889, with a 20-inch silver-on-glass reflecting telescope, and an exposure of four hours.

Direct Photo Eng. Co., Limited, 9, Barnsbury Park N.

which corresponds to the catalogue and map of M. Wolf, 1,421 stars in 1885, and they have since brought the number up to 2,326 by exposures of four hours made in November and December 1887. A difference of only twelve and a half magnitudes of the photometric scale implies that the brighter stars give 100,000 times as much light as the fainter. Mere differences of brightness in the stars composing two streams amounting to 12 or 14 magnitudes must not, therefore, be taken as reliable evidence of a difference of distance, if other facts point to an association or probable connection between the two streams.

No one who examines the accompanying plate will feel inclined to doubt that the nebulous matter shown must be associated with the large stars of the group, and that the streaks of nebulous light are associated with the small stars through which they pass. It has long been recognized that the large and irregular nebulæ, as well as the great clusters, are associated with the Milky Way, and are grouped in its neighbourhood; and one can hardly doubt that the nebulous matter associated with so many stars of the Orion group is intimately associated with the main stream of the Milky Way.

Dr. Boeddicker, in his large drawing of the Milky Way made at Parsonstown, gives a stream of nebulous light extending from the main body of the Milky Way, and including the brighter stars of Orion, a view to which probability is lent by the form and position of the numerous large nebulæ in this constellation catalogued by Dr. Dreyer and Prof. Pickering. One of these large nebulæ, streaming southward for about 60′ from the bright star ζ *Orionis*, has recently been well photographed by Dr. Max Wolf of Heidleburg, though it had previously not been overlooked by Dreyer, and had been photographed by the Brothers Henry* as well as by Prof. Pickering. A strange nebulous line of light in this Orion region, reminding one of the nebulous lines joining stars in the Pleiades group, has been photographed at Harvard. It extends from D.M. −8° 1119 in R.A. 5h. 19m. 0., Dec.−8° 40′ to D.M.−8° 1132 in R.A. 5h. 21m. 6s., Dec.−8° 50′, and passes through about sixteen faint stars.† Other lines of stars are also strikingly evident in this constellation. I have already, in the March number of KNOWLEDGE, referred to the remarkable symmetry of the curvature of the branching structures in the great Orion Nebula, with respect to an axis perpendicular to the general plane of the Milky Way. These facts leave very little doubt in my mind as to the existence of an intimate connection between the nebulous matter associated with the bright stars of the Orion group and the great stream of the Milky Way, and I am consequently led to conclude that the girdle of bright stars in which the Orion group and the Pleiades lay, is not widely separated from the stream of smaller stars forming the Galaxy, and that in any case the one cannot be so much nearer to us than the other, that the difference of apparent magnitude of the stars in the two streams may be accounted for by the difference of the distance of the streams.

It does not necessarily follow from the large parallax which has been found for α *Centauri* that it cannot belong to the stream of large stars referred to, none of which have been found to exhibit any similarly large annual shift; for the modern parallaxes, which are chiefly or entirely relied upon, are all relative and not absolute parallaxes; that is, they are determined from measures made with respect to adjacent small stars. If the adjacent stars belong to a stream which is in near proximity to the large stars, as compared with their distance from the earth, we should not expect to find any relative shift, while here and there a large star might be seen projected near to much more distant stars. On the other hand, probably, many will prefer to assume that α *Centauri* only chances to lie in a zone of brilliant stars, the rest of which are much more distant, and consequently much larger or brighter, than the star which we now recognize as our nearest neighbour.

The plate illustrating this paper has been made from a photograph kindly given to me for the purpose by Mr. Isaac Roberts. It will be noticed that the direction of the upper streak of nebulous light is continued by a line of stars which extends nearly all across the plate, and that there is a somewhat similar line of stars extending from *Pleione* (the bright star just to the north of *Atlas**) nearly across the plate just to the north of *Alcyone* and *Electra*. The eight rays crossing the brighter stars, and making them appear like the conventional symbols for stars on a star map, are due to a diffraction effect caused by the arms supporting Mr. Isaac Roberts's camera in the focus of his mirror.

* See *Rapport Annual sur l'Etat de la Observatoire de Paris pour l'Année* 1887.

† See *Annals of Harvard College Observatory*, vol. xviii., p. 115.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

ON THE COMPARISON OF THE PHOTOGRAPHS OF THE MILKY WAY IN α=17H. 56M. δ= −28° IN "KNOWLEDGE" FOR JULY 1890, AND MARCH 1891.

To the Editor of KNOWLEDGE.

DEAR SIR,—I have read with much interest Mr. Ranyard's article in KNOWLEDGE for March 1891, about the photographs of the Milky Way in 17h. 56m., −28°, made by me in 1889, and by Mr. Russell in 1890.

I have no hesitation in attributing the difference between these pictures (taken with instruments so similar) entirely to the development of the negative. As I have taken occasion to remark elsewhere (Pub. A.S.P. II. 10), the utmost care must be exercised in the development of the Milky Way pictures to bring out the cloud forms clearly and strongly.

It will be seen that Mr. Russell's photograph was given one hour and twenty minutes longer exposure than mine, and with a zenith distance on the meridian of only 6°, while the zenith distance here was 65°. The plates used for the Lick Observatory pictures were Seed, sensitometer No. 26. They are among the best that are made. I have examined Mr. Russell's photograph and can find no evidence of change in the cloud forms of the Milky Way as shown on his picture and mine. It is an extremely uncertain thing to compare two photographs like these, where one shows only feebly the cloud forms and the other shows them strongly and conspicuously. An exact comparison, however, may be made by densely overprinting the picture made here, so that the cloud forms will become as feebly shown as are those in the Sydney picture. Such a comparison I have made. The two photographs are identical in every respect, except that there are apparently several large stars near the middle of Mr. Russell's picture which are not shown on mine, and which are undoubtedly defects in his plate.

I forward to you the photograph which I have used for comparison with Mr. Russell's. You will see the two are

* For the names of the Pleiades stars, see the diagram in KNOWLEDGE for January 1889.

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identical. Yet this picture (which you would not recognize on comparison) was made from the same plate as that published in the July 1890 issue of Knowledge.

Mr. Ranyard says, at the bottom of page 50 (Knowledge for March 1891): "In Mr. Barnard's picture there are two clusters of stars near to the edge of the field at the bottom of the plate. Only one of these clusters, viz. that to the right hand, or western side, is shown in Mr. Russell's plates." It is the *left-hand*, or *following*, cluster

which is shown on Mr. Russell's picture. The right-hand one is too far to the right to be shown on his plate, though a small bunching of stars immediately following it is visible close to the right-hand edge of the picture, 2·6 inches from the bottom.

I would remark here, as a caution, that it is extremely unsafe to judge of the actual relative brightness of different surfaces, such as the Milky Way presents, from photographs which have been treated differently in point of time and development. A partially brought out configuration will have in many cases, a decidedly different aspect from that of a carefully and thoroughly developed one.

Yours respectfully,
E. E. Barnard.

Mount Hamilton, March 16, 1891.

[As mentioned in the March number of Knowledge, it is quite easy to account, by assumed differences in the method of development or differences in the sensitiveness of the plates used, for the fact that so little nebulous brightness is shown on Mr. Russell's plates as compared with Mr. Barnard's; but the remarkable fact which cannot be so accounted for is that the relative brightness of the nebulous areas on the two sets of photographs does not correspond. For example: the two brightest areas on Mr. Barnard's photographs are (1) towards the lower part of the great tree-like structure on the preceding side, and (2) a large area on the south following side of the tree-like structure. But Mr. Russell's photographs do not exhibit any trace of nebulosity in these regions, while there is distinct nebulosity shown in the fainter head of the tree-like structure. Mr. Barnard's densely-printed photograph of his own negative—which I have had reproduced as a printing-block by a photographic method—is very interesting; but I do not concur with him that the large stars near the middle of Mr. Russell's picture "are undoubtedly defects" in Mr. Russell's plate. They may be due to defects in the collotype copies which I forwarded to Mr. Barnard.—A. C. Ranyard.]

PERPETUAL CALENDARS.

To the Editor of Knowledge.

Dear Sir,—As the subject of finding the day of the week for any given date appears to interest a large section of the readers of your valuable magazine, I enclose for your acceptance (agreeably to the promise given in your February issue) a few rules bearing upon the subject of "Old Style" dates, all of which have been verified from that valuable work, Sir Harris Nicolas's *Chronology of History*. The rules appear to me to be as simple and correct as those previously given, and moreover possess the additional advantage of being serviceable "anywhere and everywhere" without the extraneous aid of discs or any other office aid.

Yours faithfully,
Robt. W. D. Cristie.

Rule I.—The last day of July of any "Old Style" date may be got thus:—

Take the year, add a quarter, divide by 7.

Example 1.—The Armenian Era commenced July 9th, A.D. 552. On what day of the week was it?

We have 552
add 138

7) 690

98 + 4 = Wednesday = 31st July.

Thus Tuesday was the 9th July 552.

Rule II.—Take the year, add a quarter, take away the the No. of the month, divide by 7. The remainder indicates the last day of month.

Example 1.—On what day of the week was March 31st, 1000?

We have 1000
add ¼ 250

1250
subtract 3 = No. of month of March.

7) 1247

178 + 1 = Sunday.

Thus March 31st, 1000 (Easter Day), fell on Sunday.

Example 2.—King Richard I. died on Tuesday, the 6th April 1199. Prove this.

1199
299

1498
3

7) 1495

213 + 4 = Wednesday = 31st March.

Thus 6th April was on Tuesday.

Example 3.—Richard II. resigned his crown on Monday, 29th September 1399. Test this.

1899
849
—
1748
9
—
7) 1739
—
248 + 3 = Tuesday = 30th September.

Thus the 29th September was Monday.

Many useful minor rules might be added, but intelligent readers can form these for themselves; and all interested in the subject of "*dates*" should provide themselves with the invaluable work mentioned above.

STATIONARY OR LONG-ENDURING RADIANTS OF METEORS.

To the Editor of KNOWLEDGE.

DEAR SIR,—Although the readers of KNOWLEDGE are already aware of the existence of Stationary or Long-Enduring Radiants of Meteors, they are not, perhaps, fully acquainted with the evidence in their favour, or of the difficulties which arise in attempting to explain them.

The evidence in favour of such long-enduring radiants will, I think, appear conclusive to anyone who arranges the observations comprised in a long catalogue, like that of Mr. Denning in the Monthly Notices of the Royal Astronomical Society for May 1890, in order of Right Ascension instead of date. I have done this with a considerable number of catalogues, which generally confirm each other. The force of this kind of evidence may be illustrated by analysing the radiants in Mr. Denning's Catalogue situated between R.A. 260° and R.A. 270° (the sign + indicating Northern, and the sign − Southern Declination). Here is a complete list of them:—

260° + 2° Apr. 19.	263° + 69° Aug. 21, 23.
260° + 33° Apr. 18.	264° + 62° Aug. 14, 23.
260° + 45° Jan. 14,17.	264° + 64° Apr. 30, May 8.
260° + 62° Apr. 19, 26.	264° + 64° May 28, 30.
260° + 63° Sept. 5, 15.	265° + 77° Apr. 26, May 3.
260° + 68° July 24.	266° + 33° Apr. 18.
260° + 69° July 27, 29.	266° + 47° Aug. 22.
261° + 4° Feb. 15, 20.	266° + 68° July 13.
261° + 5° June 3, 13.	267° + 70° Sept. 4, 7.
261° + 63° Jan. 19, 25.	267° + 21° Apr. 19.
262° + 64° May 11, 14.	267° + 49° July 15, 20.
262° + 64° June 9, 13.	268° − 24° June 10, 20.
262° + 64° Oct. 5, 12.	268° + 33° Apr. 19.
263° + 36° Feb. 20, 21.	269° + 31° Apr. 19.
263° + 48° Mar. 14.	269° + 33° Apr. 20.
263° + 61° July 29, Aug. 2.	269° + 37° Apr. 16, 19.
263° + 62° Mar. 28.	269° + 49° July 20, 31.
263° + 62° Apr. 20, 22.	

Six of these are determinations of the radiant of the Lyrids (April 18–20) in different years, but the occurrence of a radiant near the same point in February suggests a doubt as to whether even this radiant is of very brief duration. One half of the entire number appear to belong to a radiant situated between + 60° and + 70°, which continues active almost throughout the year. Five others belong to a radiant situated between + 45° and + 50°, and three to a radiant between 0° and 5°. The pair at + 20° and + 21° are also probably connected; and the isolated radiants are thus reduced to two, one at + 77° and the other at − 24°. The failure to trace the latter radiant at other times of the year probably arises from its great Southern Declination; and we thus seem led to the conclusion, not merely that stationary radiants exist, but that they are the rule—a conclusion which, I believe, further analysis of published observations will only tend to confirm.

About a quarter of a century ago the close correspondence between certain meteor-showers and the orbits of certain comets was ascertained, and since then the cometary character of meteor-showers has been generally assumed. Difficulties arise at once when we endeavour to combine this cometary character of the showers with the fact of stationary radiation. We can only fall in with a cometary shower when the earth is at a moderate distance from the comet's orbit, and if this orbit has a high inclination to the ecliptic, the corresponding shower can only be encountered when the earth is near the node. High inclinations, however, predominate among the comets (if we except the comparatively small class of comets of short period), and in the case of the comet which has been connected with the August Perseid shower the inclination exceeds 66°. But that the activity of this radiant is not limited to the month of August appears certain. Thus, Mr. Denning, on reducing the Italian observations of 1872, found that it had continued active (though with diminished intensity) during the last five months of the year. Reverting to our table, the radiant situated at about 263° + 63° is not far from the pole of the ecliptic, and therefore, if cometary, would require a high inclination in the corresponding cometary orbit; but the shower apparently lasts throughout the year. Again, if a cometary meteor-train was sufficiently diffuse to produce a shower of considerable duration, the radiant point would not be constant but would shift from night to night; whereas the constancy of the radiant (within the limits of error) is the fact with which we are dealing. Some observers, indeed, believe that they have observed a shifting in certain radiants; but the instances are few and doubtful, and the amount of observed shifting does not appear to agree well with the cometary theory.

The Copernican principle, that we perceive relative not absolute motion, is of course applicable to the apparent motions of meteors, and as the fixed stars are so distant as to be practically in the same direction at all periods of the year, the apparent motion of a meteor among the fixed stars will vary with the direction of the earth's motion at the time. Hence when the direction of the earth's motion varies (the velocity being always pretty nearly the same), the apparent position of the radiant must vary, assuming that the meteors still come to us from the same direction. But we have seen that in a great number of cases there is no perceptible change in the position of the radiant at different periods of the year, and hence arises a difficulty altogether independent of the cometary theory.

The late Mr. Proctor's solution of this difficulty is known to the readers of KNOWLEDGE. The amount of the displacement of the apparent radiant depends on the relative velocities of the earth and the meteors, and if the velocities of the meteors is very great compared with that of the earth, the displacement will be very small—and the observations are consistent with a very small displacement. But observation tends to show that meteors coming from stationary radiants do not possess this very high velocity. Few of the showers appear to be as fast as the Leonids, whose velocity has been computed from the corresponding comet at 44 miles per second. Some of them are noted by Mr. Denning as "slow" or "very slow"; and, what is perhaps the most conclusive evidence

that their velocity is comparable to that of the earth, they always (so far as I have traced) appear to move faster or slower according as the earth is receding from or approaching the radiant. The explanation of the phenomenon must therefore be sought elsewhere, but there is as yet no satisfactory theory on the subject.

It seems clear, however, either that the meteors belonging to the same long-enduring shower (though, no doubt, physically connected with each other in some way) are not originally moving in parallel lines, or else that their original parallelism is by some means destroyed before they are sufficiently heated in the atmosphere to become luminous. And this departure from parallelism (whether original or acquired) must follow a peculiar law, which almost compensates the displacement of the apparent path caused by the earth's motion. Totally unconnected meteors could not be collected into groups by terrestrial aberration in the manner that we find them collected when we analyse any calalogue ; just as a number of stones thrown at random into a current will not be collected into a heap by the action of the water. What we experience is plainly the result not of chance but of law ; but of a law which remains to be discovered.

Yours faithfully,

W. H. S. Monck.

[The degree of certainty with which meteor radiants have been determined has, I think, been generally much over-rated. Observations made during rich showers prove that the meteor-tracks drawn backwards amongst the stars do not all meet in a point, but they appear to radiate from an area of as much as five or six degrees in diameter; the reason for this divergence no doubt being that meteors are irregularly shaped bodies, which, on plunging into the air, are deflected from their original course in a manner similar to that in which an irregularly shaped body, such as a shell, is turned out of its original course when thrown into water. Occasionally meteors have such projections or irregularities that their course through the air appears sensibly curved. The degree of certainty with which a radiant can be determined depends on the magnitude of the radiant area, as well as on the number of meteors observed. If there are several radiants supposed to be active on any night, an observer has to exercise his judgment in determining which among the many intersections with other meteor-paths he will select for the radiant. No doubt the length of the meteor-path gives some indication as to whether the visible part of the track is near or far from the radiant; but the length of the path is also affected by the magnitude of the meteor and its velocity, and there must frequently be very considerable uncertainty in selecting from amongst many intersections. In such cases the bias of the observer will no doubt produce its effect. We cannot judge as to the probability of the actual existence of any radiant without knowing the number of intersecting meteor-tracks from which it has been determined. Radiants determined from only two or three intersections of meteor-paths not all observed on the same night ought, I think, to have very little weight attached to them.

I cannot accept Mr. Proctor's suggestion that such stationary radiants correspond to a rain of sporadic meteors coming from certain directions out of space ; for if the earth's motion in its orbit causes no shift of the radiant, we should have to assume such a velocity for these sporadic meteors that they would at once be detected by the different character of the streak left. According to Mr. Denning, some of the meteors from these stationary radiants are quite slow-moving.

No one has at present, as far as I am aware, plotted down all the observed radiants on a globe ; marking those which fall near together, but do not occur in the same month ; and taken a photograph of the globe to exhibit the grouping. Such a graphic method would no doubt enable the eye to judge better of the grouping, and the relation of the groups to the places of bright stars, than any inspection of tables. I have plotted down the radiants referred to in Mr. Monck's letter. They fall into three or four well-marked groups ; but the dates of the adjacent radiants are not uniformly distributed round the year, as one would expect on Mr. Monck's hypothesis.—A. C. Ranyard.]

THE FACE OF THE SKY FOR MAY.

By Herbert Sadler, F.R.A.S.

BOTH spots and faculæ continue to appear on the solar surface. The following are the times of minima of some of the Algol type variables (*cf.* Knowledge, March and April, 1891), which may be conveniently observed at Greenwich.

U Cephei.—May 4th, 0h. 31m. A.M. ; May 9th, 0h. 11m. A.M. ; May 13th, 11h. 51m. P.M. ; May 18th, 11h. 31m. P.M. ; May 23rd, 11h. 11m. P.M. ; May 28th, 10h. 50m. P.M.

S Cancri.—May 7th, 11h. 51m. P.M. ; May 26th, 11h. 7m. P.M.

δ Libræ.—May 7th, 6h. 44m. P.M.

U Coronæ.—May 14th, 0h. 27m. A.M. ; May 20th, 10h. 9m. P.M. ; May 27th, 7h. 51m. P.M.

Owing to his proximity to the sun, Mercury is not well situated for observation in May. On the 1st he sets at 8h. 39m. P.M., or 1h. 18m. after the sun, with a northern declination of 20° 27′, and an apparent diameter of $10\frac{3}{4}''$. He is then inferior to a 5th-magnitude star in brightness, about $\frac{7}{100}$ of the disc being illuminated. He is in inferior conjunction with the sun at 3h. A.M. on the 10th, at a distance of about $51\frac{3}{4}$ millions of miles from the earth, being then in transit over the solar disc ; a phenomenon which may be well observed in the western part of the United States and of South America. At Greenwich the sun rises at 4h. 18m. A.M. on that day, and external contact at egress takes place at 4h. 50m. 25s. A.M., at an angle of 168° from the north pole towards the west (counting for direct image). At egress the sun will be only about 4° above the horizon at Greenwich. After this Mercury becomes a morning star, but is too near the sun to be observed, as on the 31st he only rises 36m. before that luminary.

Venus is a morning star, but is too near the sun to be very conveniently observed. On the 1st she rises at 3h. 37m. A.M., or 57m. before the sun, with a northern declination of 0° 49′, and an apparent diameter of $13\frac{1}{2}''$, eight-tenths of her disc being then illuminated. On the 31st she rises at 2h. 46m. A.M., or 1h. 5m. before the sun, with a northern declination of 13° 45′, and an apparent diameter of $11\frac{1}{2}''$. She has then only a little more than a quarter of the brightness she possessed at the beginning of January, about $\frac{87}{100}$ of her disc being illuminated. During the month she passes through Pisces into Aries, but without approaching any conspicuous star very closely.

Mars and Jupiter may be considered to be, for the purposes of the amateur, invisible. Saturn is an evening star, rising on the 1st at 1h. 20m. P.M., with a northern declination of 9° 37′, and an apparent equatorial diameter

of 18½″ (the major axis of the ring system being 42½″, and the minor 4·0″). On the 31st he rises at 11h. 22m. A.M., with a northern declination of 9° 28′, and an apparent equatorial diameter of 17½″ (the major axis of the ring system being 40¼″, and the minor 3¾″). On the evening of the 5th Titan is about 20″ south of the planet; and on that of the 12th about 22″ north. On the 14th Iapetus is about 35″ south of Saturn. On the evening of the 21st Titan is about 20″ south of Saturn, and may just possibly be eclipsed by the shadow of the planet. On the evening of the 28th Titan is *nf* of the planet. Uranus is an evening star, rising on the 1st at 6h. 0m. P.M., with a southern declination of 10° 33′, and an apparent diameter of 3·8″. On the 31st he rises at 8h. 55m. P.M., with a southern declination of 10° 11′. He describes a short retrograde path to the N.N.E. of 86 Virginis during the month. Neptune is in conjunction with the sun on the 28th. There are no well-marked showers of shooting stars in May.

The moon enters her last quarter at 1h. 51m. P.M. on the 1st; is new at 6h. 16m. A.M. on the 8th; enters her first quarter at 7h. 4m. P.M. on the 15th; is full at 6h. 26m. P.M. on the 23rd; and enters her last quarter at 6h. 55m. P.M. on the 30th. She is in perigee at 9h. A.M. on the 5th (distance from the earth 227,015 miles), in apogee at 5h. A.M. on the 17th (distance from the earth 251,380 miles), and in perigee again at 9h. A.M. on the 31st (distance from the earth 229,565 miles). The greatest western libration is at 4h. 10m. A.M. on the 11th, and the greatest eastern at 0h. 44m. A.M. on the 24th. There will be a total eclipse of the moon on the 23rd, which may be well observed in India. At Greenwich only a small portion of the eclipse is visible; the moon rising at 7h. 56m. P.M., and totality ending three-quarters of an hour previously. The last contact with the shadow takes place at 8h. 17m. P.M., at an angle of 90° from the northernmost portion of the moon's limit towards the west (counting for direct image). The last contact with the penumbra takes place at 9h. 21½m. P.M.

Whist Column.

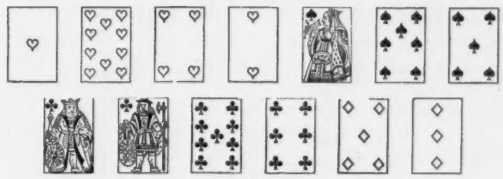
By W. MONTAGU GATTIE, B.A.Oxon.

THE MANAGEMENT OF TRUMPS.

AT the commencement of a hand, the question whether or not trumps should be led, although often difficult. can nevertheless be decided, in the large majority of instances, on certain definite lines familiar to players of experience. Differences of opinion exist, no doubt, as to the proper course in particular cases, and there is wide scope for diversity of style. There is, perhaps, no point of the game into which the "personal equation" enters more conspicuously, and a man's position in a scale of character ascending from the extreme of caution to the extreme of temerity might not inaccurately be gauged by his management of trumps. But, given a particular player, he will nearly always be able to decide, as soon as he takes up his cards, whether he will lead trumps or not.

The case is different when the game has progressed some stages, and when, at a critical moment, the question of a trump lead has to be determined. General rules have ceased to be applicable, and there is no longer so much margin for individuality. The only safe guides are judgment and observation, and these are the distinguishing marks of the brilliant player. The following hand furnishes an interesting example of the importance attaching to a right decision under such circumstances:—

HAND NO. 20.



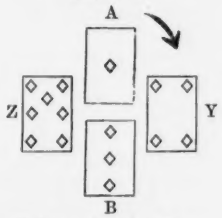
B's Hand.

Score—AB, love; YZ, 3.

Z turns up the ace of clubs.

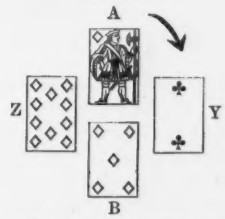
NOTE.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

TRICK 1.



Tricks—AB, 1; YZ, 0.

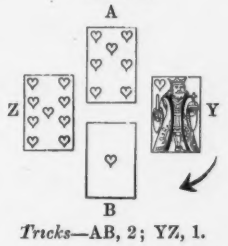
TRICK 2.



Tricks—AB, 1; YZ, 1.

NOTE.—*Trick* 2.—Z has the king of diamonds; A has all the other diamonds; and Y, having ruffed a doubtful trick, is weak in trumps.

TRICK 3.

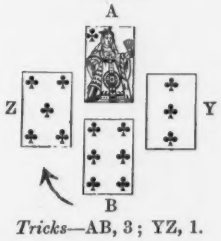


Tricks—AB, 2; YZ, 1.

NOTE.—From the fall of the cards, Y has led from at least six hearts; he holds the queen, and not the knave. A can only have the knave, eight; and Z can only have the knave, unless he has commenced a call for trumps.

FIRST LINE OF PLAY.

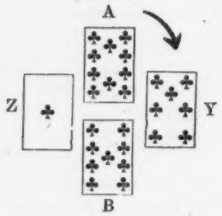
TRICK 4.



Tricks—AB, 3; YZ, 1.

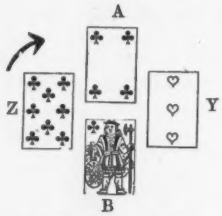
NOTE.—B desires neither to open spades, nor to lead hearts up to Y's strength. Holding four trumps to two honours, he leads through Z's ace up to Y's declared weakness.

Trick 5.



Tricks—AB, 3; YZ, 2.

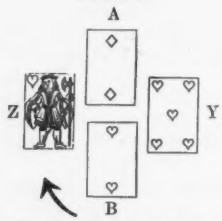
Trick 6.



Tricks—AB, 4; YZ, 2.

Note.—Z's lead was to be expected, for his partner clearly has no more trumps, and the four is marked in A's hand.

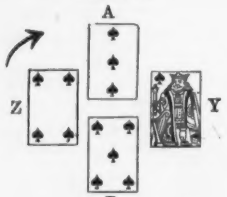
Trick 7.



Tricks—AB, 4; YZ, 3.

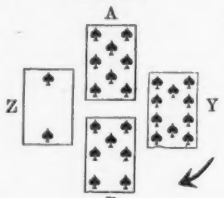
Note.—B's lead will either clear his ten of hearts, or throw the lead into Z's hand, who then must open spades. A spade is of no avail, unless both A's spades are winning cards (the diamonds being not yet established); and, in this fortunate event, only one trick is lost by the heart lead.

Trick 8.



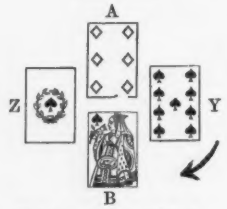
Tricks—AB, 4; YZ, 4.

Trick 9.



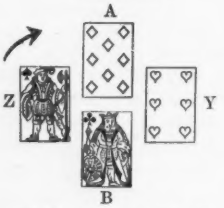
Tricks—AB, 4; YZ, 5.

Trick 10.



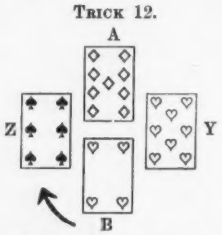
Tricks—AB, 4; YZ, 6.

Trick 11.



Tricks—AB, 5; YZ, 6.

Trick 12.



Tricks—AB, 5; YZ, 7.

Y makes the queen of hearts, and

YZ Score Two by Cards and Game.

Remarks.—If B leads a small spade at trick 7, Y, on winning with the nine, should return the king at once, and follow with the ten; Z wins with the knave, draws B's trump with the ace, and then makes the knave of hearts, the king of diamonds, and the last spade.

Trick 8.—It would, of course, be bad play at this stage of the game for Z to lead out the ace of spades.

Trick 9.—Z passes his partner's ten; for, if B holds queen, nine, he can only have one heart, and, after trumping Y's hearts, must lead a spade.

Second Line of Play.

Trick 4.—B plays the two of hearts, Z the knave of hearts, A the four of clubs, Y the three of hearts. *Tricks*, AB, 3; YZ, 1.

Note.—B argues that, if A has knave, eight, of hearts, he can only have three trumps, and these on the hypothesis that he has no spades, so that there is small prospect of his bringing in his diamonds, which are not yet established. If A has no hearts, AB have a cross ruff; if he has the eight, and Z the knave, B's ten will remain guarded; and, if Z is void and discards, A's knave will draw the queen, and B will have command of the suit.

Trick 5.—A plays the eight of diamonds, Y the seven of clubs, B the nine of clubs, Z the king of diamonds. *Tricks*—AB, 4; YZ, 1.

Trick 6.—B plays the four of hearts, Z the two of spades, A the ten of clubs, Y the five of hearts. *Tricks*—AB, 5; YZ, 1.

Trick 7.—A plays the queen of diamonds, Y the three of clubs, B the king of clubs, Z the ace of clubs. *Tricks*—AB, 5; YZ, 2.

Note.—A asks B for his best trump.

Trick 8.—Z plays the five of clubs, A the queen of clubs, Y the six of hearts, B the six of clubs. *Tricks*—AB, 6; YZ, 2.

Trick 9.—A plays the nine of diamonds, Y the nine of spades, B the ten of hearts, Z the eight of clubs. *Tricks*—AB, 6; YZ, 3.

Trick 10.—Z plays the four of spades, A the three of spades, Y the king of spades, B the five of spades. *Tricks*—AB, 6; YZ, 4.

Trick 11.—Y plays the queen of hearts, B the knave of clubs, Z the six of spades, A the two of diamonds. *Tricks*—AB, 7; YZ, 4.

Trick 12.—B plays the seven of spades, Z the ace of spades, A the eight of spades, Y the ten of spades. *Tricks*—AB, 7; YZ, 5.

Trick 13.—B makes the queen of spades, and

AB Score Two by Cards and Two by Honours.

Remarks.—*Trick* 6.—If Z trumps with the ace, A discards a spade; and, if Z then leads a trump, AB, with proper play, make 4 by cards.

Trick 10.—Z plays correctly in leading a small spade, as he can count two spades in A's hand and three in B's.

Trick 12.—Z, of course, plays his ace of spades to save the game, as he cannot tell where the queen is.

A's Hand.	B's Hand.
C.—Qn, 10, 4.	C.—Kg, Kn, 9, 6.
D.—Ace, Qn, Kn, 9, 8, 6, 2.	D.—5, 3.
S.—8, 3.	S.—Qn, 7, 5.
H.—7.	H.—Ace, 10, 4, 2.

Y's Hand.	Z's Hand.
C.—7, 3, 2.	C.—Ace, 8, 5.
D.—4.	D.—Kg, 10, 7.
S.—Kg, 10, 9.	S.—Ace, Kn, 6, 4, 2.
H.—Kg, Qn, 8, 6, 5, 3.	H.—Kn, 9.

Chess Column.

By C. D. Locock, B.A.Oxon.

To Correspondents.—Solutions of Problems should be sent in not later than the 12th of each month, for acknowledgment in the following number.

Correct solution of Problem No. 1 received from A. F. Parbury.

C. T. Blanshard.—After 1. B to KB2, R to K5, White cannot mate. See below for correct solution. The problem you send is rather too simple, the move to block the position being obvious. You might, perhaps, puzzle your friends with the following:—White: K at K2, Q at Q2. Black: K at K5, Pawns at K4 and KB4. Mate in 2.

Solutions of Problems.

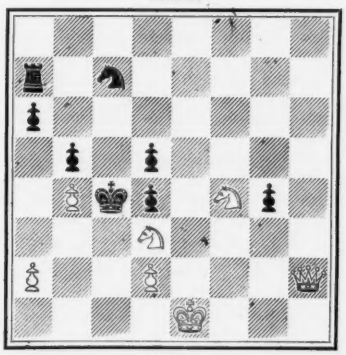
No. 1 (Two-mover, by T. Taverner).—1. R to Rsq, and mates next move.

No. 2 (Fifteen-move Sui-Stalemate, by C. D. Locock).—1. B to B3 ch, 2. Q to B5 ch, 3. R×B ch, 4. Q to K6 ch, 5. P×R (Queening) ch, 6. R to Q6 ch, 7. Q to QR8 ch, 8. Kt to B7 ch, 9. P to Kt4 ch, 10. Q to Kt8 ch, 11. Kt to R8 ch, 12. Q×B ch, 13. Kt to Kt6 ch, 14, Kt to R4 ch, 15. Q to Kt5 ch, K×Q, Stalemate. Blacks moves are all forced.

PROBLEM.

By J. Mortimer.

Black.



White.

White to play, and mate in three moves.

CABLE MATCH.

(Steinitz *v.* Tschigorin.)

We give here the first stage of the "Two Knights Game," with notes.

Two Knights Defence.

White. Steinitz.	Black. Tschigorin.
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to QB3
3. B to B4	3. Kt to KB3
4. Kt to Kt5	4. P to Q4
5. P×P	5. Kt to QR4
6. B to Kt5 ch	6. P to B3
7. P×P	7. P×P
8. B to K2	8. P to KR3
9. Kt to R3 (*a*)	9. B to QB4 (*b*)
10. P to Q3	10. Castles (*c*)
11. Kt to B3 (*d*)	11. Kt to Q4
12. Kt to R4 (*e*)	12. B to Q3
13. Kt to Ktsq (*f*)	13. P to KB4
14. P to QB3 (*g*)	14. B to Q2 (*h*)
15. P to Q4	15. P to K5 (*i*)
16. P to QB4	16. Kt to K2 (*j*)
17. Kt to QB3	17. B to K3
18. P to QKt3	18. B to QKt5
19. B to Kt2	19. P to B5 (*k*)
20. Q to B2 (*l*)	20. Q×P
21. K to Bsq (*m*)	21. P to B6
22. P×P	22. P×P
23. B×P (*n*)	23. B to KB4 (*o*)
24. Kt to K4 (*p*)	24. B×Kt
25. Q to K2 (*q*)	25. B×B
26. Q to K6 ch	26. K to R2 (*r*)
27. B×Q	27. B×R

(*a*) Up to, and including this move, the line of play was agreed on by the two players.

(*b*) Captain Mackenzie was inclined to prefer 9. . . . B to Q3. White, however, seems to have a good reply in 10. P to Q4. After 9. . . . B×Kt?; 10. P×B, Q to Q4; 11. B to B3, P to K5; 12. Kt to B3, Q to K4; White wins by 13. Q to K2, which seems better than 13. B to Kt2, the move given by Mr. Steinitz in his *Modern Chess Instructor*.

(*c*) 10. . . . Kt to Q4 would be good, but for the reply 11. B to Kt4. He dare not play 11. Kt to B3, B×Kt; 12. P×B, Kt×Kt; 13. P×Kt, Q to R5, recovering the Pawn. In the above variation, if White play 12. Kt×Kt, Black wins at once by 12. . . . B×P, or, in a more roundabout way, by 12. . . . Q×Kt; 13. B to B3, Q to Q5; 14. B to K3, Q to Kt5 ch; 15. P to B3 (if 15. B to Q2, Q to KR5 wins), 15. . . . Q×KtP, winning another Pawn. Immediately fatal would be 11. Kt to Q2??, B×Kt; 12. P×B, losing the Queen.

(*d*) 11. P to QB3 also presents claims to consideration. Not so, however, 11. B to K3, for Black would exchange both pieces and proceed with Kt to Q4, threatening Q to R5 ch, or Q to Kt3, according to circumstances.

(*e*) 12. Kt×Kt, besides presenting Black with a centre, would allow his QKt to escape at QB3, bringing the game to a kind of Evans Gambit position.

(*f*) In view of the adverse KBP coming on, he no longer relishes the idea of B×Kt, a capture which would have been obviously imprudent on the previous move, on account of 13. Kt×B, B×P?; 14. R to Ktsq, &c.

(*g*) A characteristic move (*vide* note (*i*)). After 14. P to Q4, P×P; 15. Q×P, Black, according to Mr. Steinitz, has a good game. He might continue 15. . . . Q to K2, preventing Kt to B5, and threatening 16. . . . Kt to Kt 5, and other terrors.

(*h*) A very ugly-looking move. B to K3 has, at any rate, a more attractive appearance (*vide* move 17).

(*i*) Hear now the Master: "If Black had played P×P, I should have retaken with the Pawn, creating two 'holes' in Black's game at K4 and QB4." So isolated Pawns are not so bad always after all! In this case the compensation partly lies in the open QB file.

(*j*) Mr. Steinitz would probably answer B to Kt5 ch? by K to Bsq, or Kt to B5 by B to Bsq.

(*k*) A little premature, perhaps. He might play instead 19. R to Ktsq, preventing P to QR3. If then 20. P to KB4, Black might venture . . . P to KKt4, followed by Kt to

XUM

Kt3. 20. . . . Kt to Kt3 at once would be useless on account of 21. P to Kt3, and if Black sacrifices the Knight the White King escapes to QB2. Mr. Tschigorin's object, no doubt, was to prevent P to KB4, even though that move would give him a passed Pawn.

(*l*) A very fine move, if properly followed up. Black is practically bound to take the offered Pawn, or White could Castle (against his principles) on the Q side.

(*m*) "Steinitz's Delight." Moreover it threatens to win a piece by P to QR3. At the same time, with all due deference, it is difficult to describe it (followed up as it is) otherwise than as an extraordinary blunder, occurring as it does in a correspondence game. White might have obtained the superiority by the following simple line of play: 21. P to QR3, B × Kt (forced); 22. B × B, Q to Kt3! (If Q to Qsq, White wins a piece by Q × P and Q to K5); 23. Q × P, P to B3!; 24. P to QKt4, Kt to Kt6; 25. R to Qsq, followed by Kt to R3.

(*n*) If 23. Kt × P, B to R6 ch; 24. K to Ksq, with a good enough game. Black is still a Pawn to the bad, and his attack is, to say the least, not obvious.

(*o*) The best, and in fact the only move, as White threatens P to QR3 followed by Kt to K4.

(*p*) Another extraordinary blunder. Q to Bsq was the only move. B to K4 would obviously lose a piece. The same result would attend Q to Qsq, on account of the reply B to Q6 ch.

After 24. Q to Bsq, B to Q6 ch (better than B to R6 ch, to which White could reply 25. K to K2); 25. QKt to K2!, Q to R5; 26. Q to K3, with a good game.

It should be noticed that 25. K to Kt2 was out of the question on account of the winning reply R × B! 25. K to Ksq was also dangerous in view of QR to Ksq. (Not, however, 25. . . . R × B; 26. Kt × R, Q to K5 ch; 27. Q to K3, Kt to B4; 28. Q × Q, B × Q; 29. K to K2 and wins).

(*q*) He perceives now, what he must have overlooked at move 21, that 25. B × B would lose on account of 25. . . . R × P ch!; 26. Q × R, Q × B; 27. Kt to B3, R to KBsq; 28. K to Kt2, B to B4!; 29. Q to Kt3, Q to B7 ch, &c.; or, better still, 29. . . Kt. to B4. Mr. Tschigorin, of course, takes advantage of the move actually made, to give up his Queen for more than an equivalent both in material and position.

(*r*) A learned commentator in an unlearned contemporary suggests here 26. . . . K to Rsq, as leaving the King less subject to checks. He would be subject, however, to a mate in two moves, which White might announce after 27. B × Q, B × R.

After the next move on each side the game enters on a new phase, the consideration of which, in view of the alphabet running short, is postponed till the conclusion of the game.

The following additional moves have been made in this game :—

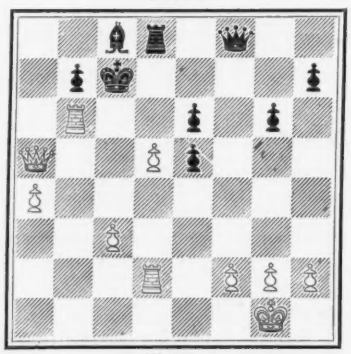
WHITE.	BLACK.
28. Q to R3!	28. Kt to B4
29. B to K5	29. QR to Ksq
30. B to B4	30. Kt to Q5
31. Q to Q3 ch	31. B to K5
32. Q × Kt	32. R × B
33. P to B3	33. QR to KBsq
34. Q × RP	34. P to B4
35. Q to QB7	35. Kt to B3
36. P to QR3.	36. R × P ch!
37. Kt × R	37. R × Kt ch

The Evans Gambit game has been continued as follows since the publication of the diagram in the March number :—

WHITE (Tschigorin).	BLACK (Steinitz).
21.	21. B to Q3
22. Kt to R4	22. Kt × Kt
23. Kt to B5	23. P to KKt3
24. Kt × B	24. Q × Kt
25. B × Kt	25. BP × B
26. B × P	26. R to QRsq
27. Q × R	27. Q × B
28. Q to R4	28. K to Qsq
29. R to Q2	29. K to B2
30. R to Ktsq	30. R to Qsq
31. R to Kt5	31. Q to B3
32. Q to Kt4	32. P to Q3
33. P to QR4	33. Q to Ksq
34. R to Kt6	34. Q to Bsq
35. Q to R5	35. P to Q4
36. P × P	

(*Present Position*).

BLACK.



WHITE.

The news of the death of Captain G. H. Mackenzie has been received in England with the greatest regret. Besides being for a great many years the strongest player in America, Captain Mackenzie was perhaps the most universally popular of all the chess masters. As a player he takes rank only after Mr. Steinitz and the late Dr. Zukertort.

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Communications for the Editor and Books for Review should be addressed Editor of "KNOWLEDGE," care of DAVID STOTT, Bookseller, 67 Chancery Lane, W.C.